Study of River Channel Changes and Channel Shifting near Ngawun Bridge (Myo-kwin)

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***Abstract**: River morphology changes is one of the key issues in Myanmar which cause impacts on navigation, riverine habitats, agriculture lands, communities and livelihoods near the bank of the river. This study analysis the river channel change by the Ngawun River by using Geographic Information Systems (GIS) techniques and Google Earth Engine (GEE). This study aimed to track the changes in river morphology in Ngawun River over last 20 years from 1990-2016 and describe river channels how they change over time. The bank erosion of the river started at the west bank near pier number I_2 of the Ngawun Bridge after the construction period in 2011. Earth observations include LandSat-5, LandSat-7 and LandSat-8 .GIS is used to analyse changes in river channel change and river shifted direction.*

***Key Words:** river morphology, river shifted direction, Ngawun River, LandSat, Google Earth Engine.*

1. INTRODUCTION:

Riverbank erosion is a natural process, but often anthropogenic activities can have significant impact on the rates of morphological change. River channel changes, such as bank erosion, down cutting and bank accretion, are natural processes for an alluvial river. Bank erosion is not a single process. It encompasses a wide variety of hydraulic and gravitational mass failure processes. Changing water level, flooding flow direction and higher flow velocity, contributed by climate change, are main causes of bank erosion. Bank erosion has negative impacts on people livelihood along the river bank (expenditure, properties, income, increase sediment in water and other issues). Related soil characteristics and flow direction of water cause bank erosion.

In most outer bends, the scour pool is located close to these outer eroding banks. The depth of outer bank scour increases as flow intensity increases. As stream flow moves through a bend, the tractive force along the outer bank increases. The tractive force increases as the water velocity and depth of flow increase. Consequently, erosion in bends is generally much greater than in straighter reaches. Therefore, the erosive forces are generally greater at higher flows. In bends, there is a concentration of flow due to centrifugal forces. This causes the depth to increase at the outside of the bend and causes thalweg flow (deepest flow) near outer bank.

River morphology is a complex subject, which can be subdivided into several different areas that are often related to each other. Erosion is affected by many natural factors such as rainfall, vegetation cover, river bank soil stability, river sediment, bedrock characteristics, relief-slope characteristics, and hydraulic conditions.

Major causes of erosion are currents, strong river discharge, high waves, and increases of population. Over time, the river responses by changing in channel cross section, increased or decreased sediment carrying capacity, erosion and deposition along the channel, which affect bank stability and even morphology changes.

2. LITERATURE REVIEW:

River Morphology

River morphology is the shape or form of a river along its length and across its width or field of science dealing with changes of river form and cross-section shape mainly due to sedimentation and erosion processes. Channel morphology is the result of mutual interactions of four broad categories of variables such as fluid dynamics (which include velocity, discharge, roughness and shear stress), channel character or channel configuration (e.g. channel width, channel depth, channel slope, channel shape, channel pattern etc.), sediment load and bed and bank materials (composition and character i.e. coarse, fine, medium etc.).

A. River Classifications

A very general classification of rivers takes consideration of their age. One of the early methods to classifyrivers was by relative age as youthful, mature, and old. As a general concept this has validity with steep irregular young streams becoming mature with a narrow valley, a floodplain, and a graded condition; that is, the slope and energy of the streams are just sufficient to transport the materials delivered to it. As time passes, the valley widens and a fully meandering channel of low gradient develops.

More recently, rivers have been classified based upon type of sediment load, and pattern. Nevertheless, the concept of landform and channel evolution through time is a valuable one.

In the context of a rivers age, the process of channel rejuvenation refers to an increase in erosional activities in mature or old channels caused by lowering base level elevation, tectonic activities or other causes. Rejuvenated mature or old channels then exhibit some properties of youthful channels such as channel incision and erosion processes.

Geographic Information Systems (GIS)

ArcGIS software is used for georeferencing and digitizing UTM maps. Digital image-processing software.. Flow direction, flow accumulation and watershed are generated using ArcMap from Digital Elevation Model to define the study area. Landsat data and collateral data are used for preparation of various thematic maps as spatial data base. The images are selected based on having no cloud cover in the study area, and for having been observed at similar seasons. The images selected are taken during the dry season when cloud-free imagery is available and when water level, vegetation cover and other ground conditions are relatively consistent.

A Geographical Information System (GIS) is a system of hardware, software and procedures to facilitate the management, manipulation, analysis, modeling, representation and display of geo-referenced data to solve complex problems regarding planning and management of resources. Functions of GIS include data entry, data display, data management, information retrieval and analysis. The applications of GIS include mapping locations, quantities and densities, finding distances and mapping and monitoring change. Function of an Information system is to improve one's ability to make decisions. An Information system is a chain of operations starting from planning the observation and collection of data, to store and analysis of the data, to the use of the derived information in some decision making process. A GIS is an information system that is designed to work with data referenced to spatial or geographic coordinates. GIS is both a database system with specific capabilities for spatially referenced data, as well as a set of operation for working with data. There are three basic types of GIS applications which might also represent stages of development of a single GIS application.

Remote Sensing Technology

Remote sensing is the technique of deriving information about objects on the surface of the earth without physically coming into contact with them. This process involves making observations using sensors (cameras, scanners, radiometer, radar etc.) mounted on platforms (aircraft and satellites), which are at a considerable height from the earth surface and recording the observations on a suitable medium (images on photographic films and videotapes or digital data on magnetic tapes). When electromagnetic radiation falls upon a surface, some of its energy is absorbed, some is transmitted through the surface, and the rest is reflected. Surfaces also naturally emit radiation, mostly in the form of heat. It is that reflected and emitted radiation which is recorded either on the photographic film or digital sensor. Since the intensity and wavelengths of this radiation are a function of the surface in question, each surface is described as processing a characteristic ″Spectral Signature″. If an instrument can identify and distinguish between different spectral signatures, then it will be possible to map the extent of surfaces using remote sensing. Satellite remote sensing is widely used as a tool in many parts of the world for the management of the resources and activities within the continental shelf containing reefs, islands, mangroves, shoals and nutrient rich waters associated with major estuaries

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Google Earth Engine (GEE)

The Google Earth Engine is a platform combining a multi-petabyte catalogue of satellite imagery and geospatial datasets with planetary-scale analysis capabilities and is available for everyone to detect changes, map trends, and quantify differences on the Earth's surface (Google Earth Engine).It is thus a tool for analyzing geo-spatial information with an application programming interface which is available in Python and JavaScript.

The application used in this study to process satellite data, is the free of use Google Earth Engine (GEE). This is a platform where all types of open source satellite data (Landsat, Sentinel, SRTM, etc.) can be processed and mapped. This can also be combined with all types of location specific data, which can be uploaded via Google Fusion Tables. A large advantage of this platform is that it gives access to all data measured with satellite (so more than only images visible with human eye). This gives the possibility to make extensive analysis. The processing is done with scripting, which can also easily be shared and re-used. The used bands are short wave infrared, near infrared, green, red and blue.

Data availability

The GEE data catalogue shows a variety of different datasets. Images from different satellite images providers such as MODIS, LANDSAT, SENTINEL or digital elevation data from the Shuttle Radar Topography Mission (SRTM) are accessed with suitable condition. In addition to that, the GEE data catalog includes satellite data in raw format, orthorectified imagery, top-of atmosphere- and surface reflectance data.The GEE data catalog serves as a basis for most of the calculation within the GEE environment as one's codes work best when staying inside this environment. Importing additional data is possible but often limits the use of built-in functions especially designed to work with data from the GEE data catalog.

3. STUDY AREA:

Myanmar is situated in the mainland South East Asia with the total area of 677,000 square kilometers, which is well endowed with natural river resources of the Ayeyarwaddy, the Chindwin, the Sittaung, the Thanlwin, the Mekong and numerous small rivers. Ngawun Bridge (MyoKwin) (17°42' 38.65"N, 95°12' 27.71"E) is selected for study area. It locates over the Ngawun River in Ayeyarwaddy division. It joins with Hinthada and Ingapu side. It is long 2835 ft that is composed of 1035 ft of main span and 960 ft of approach span to Hinthada and 840 ft to Ingapu side. It was started on March 2005 and opened on March 2009. Ngawun River is the first and western most distributary of the Ayeyarwady River in Ayeyarwady Division. It flows from north to south and is 180 miles long. Many tributaries enter into the Ngawun River from the eastern and western sides. It experiences annually floods during the peak monsoonperiod especially in July and August.especially in July and August.

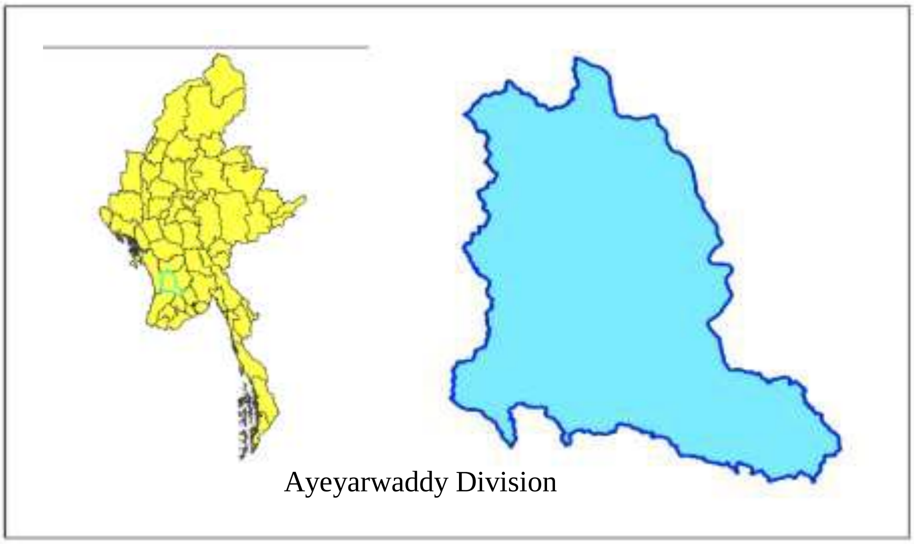


Fig 1(a). Location of study area

Fig.1(b). Location of Ngawun Bridge (Myo-Kwin)

4. METHODOLOGY:

Use long-termed Landsat imagery (LandSat 5, 7 and LandSat 8).A series of long termed Landsat images during 1990-2016 periods is created for the Ngawun River. The satellite (LANDSAT) images were collected and analysed for determining the shift of bank line. The satellite images of 1990 to 2016 were collected for this purpose.USGS Landsat 8 TOA Reflectance of 2016, 2014 image collection is selected to know the mean of normalized difference water index (NDWI).True color composite B3_mean and B5 _mean are selected and filtered by date. Then USGS Landsat 7 Collection 1 Tier 1 TOA of 2010, 2009 image collection is used to get NDWI_2010.USGS Landsat 5 TM collection 1 Tier1 of 2001, 2007 image collection is another import entry. Median size of B2_median and B4_median are selected for NDWI_2000.Filter all period from 01 March to 31 May. Use image reducer to get image selection of selected year. Finally, creating color composite of NDWI of 2000, 2010 and 2016 are done. After that, export the image specifying scale and region. Then, compare and analyse river morphology changes and river channel shifting direction in GIS.

Observations from satellite imagery

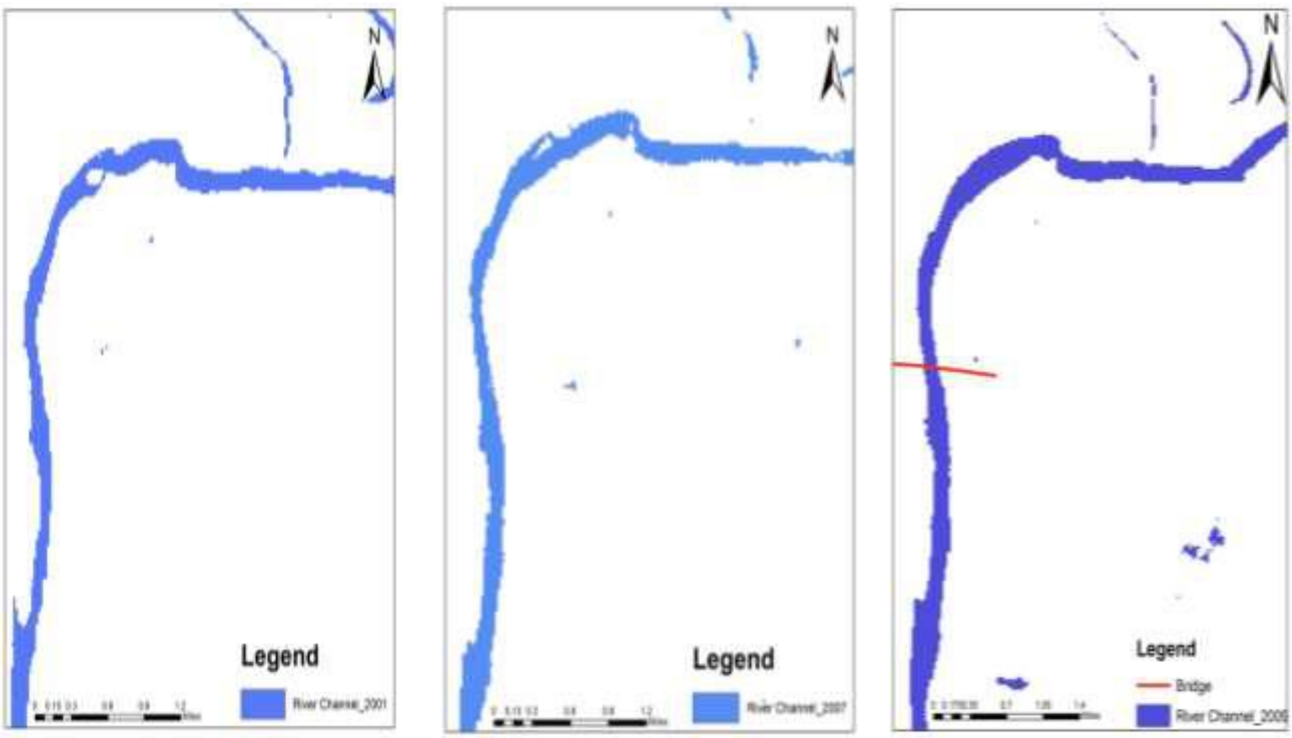
The research area is analysed from satellite data. Data was used of Landsat 5, 7 and 8, which covers the years 1990 to 2016. The data was processed using the Google Earth Engine. Processing existed of two parts. The first part was the creation of cloud free images from all the data available of every dry season. These average reflectance composites are used throughout the whole report and show the average channel pattern as it can be observed during the dry season. The assumption is made that during the dry season the water images have a similar wet surface, where there might be some differences when water levels are not the same. The second part was the automatic detection of water which is useful for the visualization of water masks in different years.

5. RESULTS AND DISCUSSION:

River Planform Changes in the Study Reach

The river channel shifted to the West in upstream and to the East in downstream of the bridge between 2001-2016. River was moved within 15 years from 2001 to 2016 eroding the West bank and depositing in the East. The changes of river channel from 2001 to 2016 were very dynamic and unstable. River meander was shifted from the West to the East eroding the East bank and depositing in the West with translation and expansion planform change in which case water is forced on the outside of the river bend and consequently erosion occurs on the river outer bank shown in Fig; 2 .There are, of course, plenty of irregular meanders along the study river reach in all study years; 2001, 2007,2009,2010,2014 and 2016.

Data analysis of the over last two decades from 1990 to 2016 by GIS shows that the area of erosion and deposition are different. Transportation of sediment is the major contributing factor of morphological changes. This type of study is helpful for further planning of river training and management in an effective manner as it could be incorporated the long time (historical) changes of the river morphology.



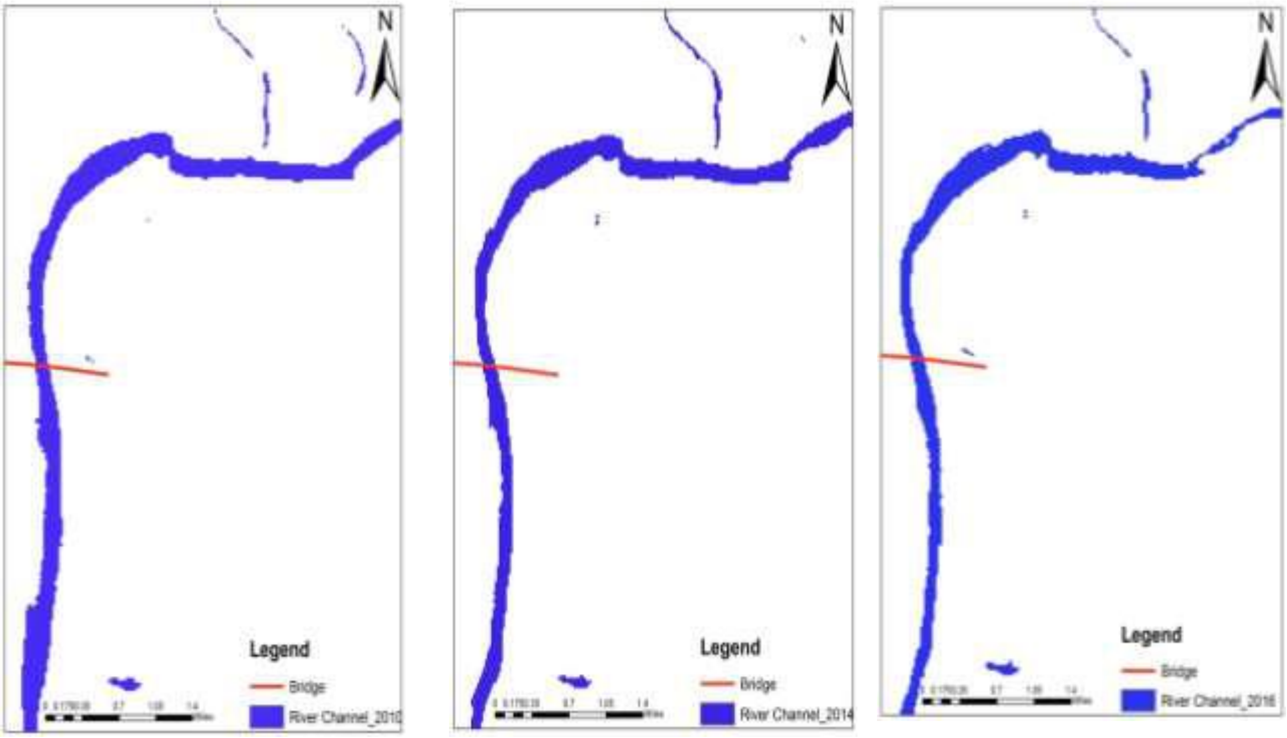


Fig.2. River planforms in 2001, 2007,2009,2010,2014 and 2016

Morphological Changes before Construction of Bridge

First 3 periods (1990, 1995 and 1999) are considered how to change river yearly time series with GEE. The channel changed obviously in 1999.River meander was shifted from East to West within five years with translation change pattern of the river movement. Then, deposition took place in West with translation and expansion river planform change in which case water forced on the outside of the river bend and consequently erosion occurred on the river outer bank shown in Fig.3.

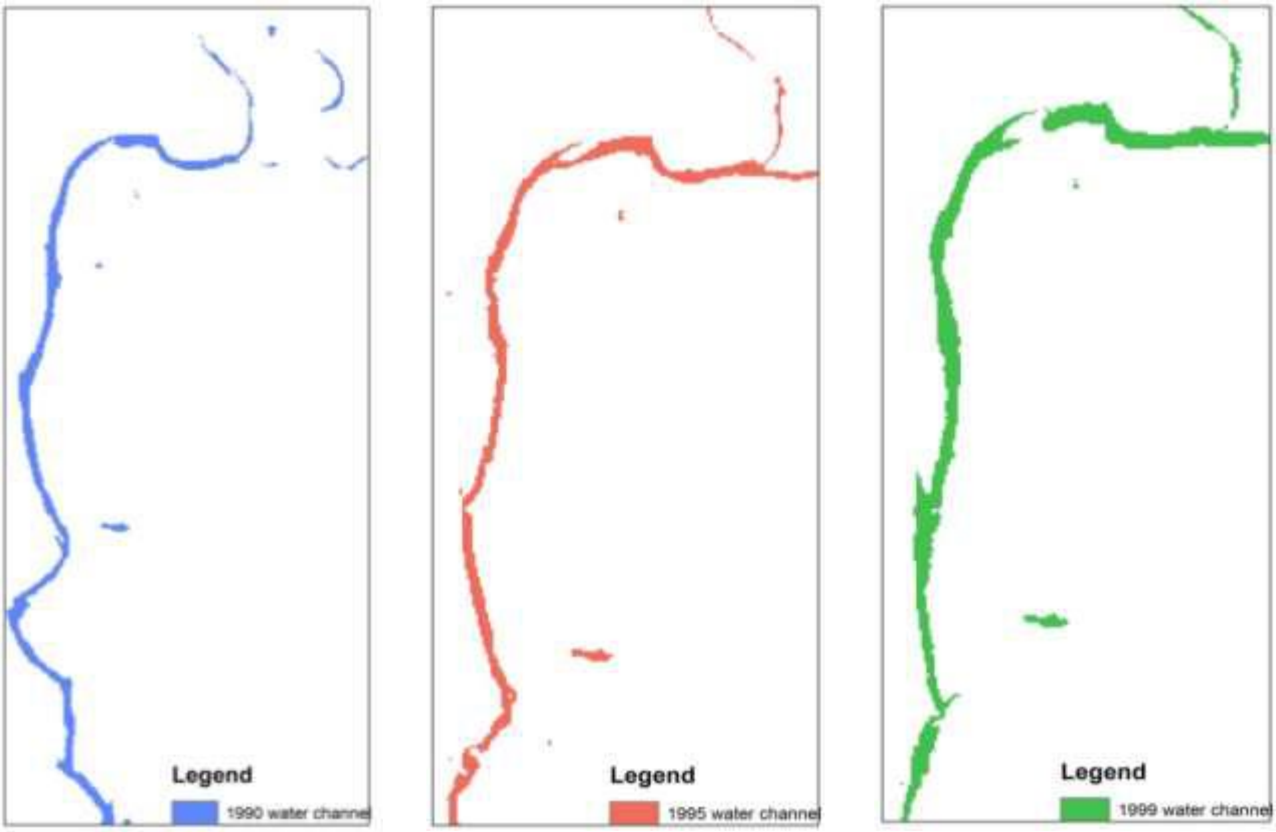


Fig.3 Changes of river channel in 1990, 1995 and 1999

River Channel Shifting

Comparison of the river channel shifting is carried out in five phases,2001-2007,2007-2009,2009-2010,2010-2014 and 2014-2016 for both the riverbanks by GIS analysis. Maximum channel movement was 87 meter and minimum channel movement was 1.65 meter about 800 meters upstream of the bridge.

TABLE I
RIVER SHIFTED DIRECTION UPSTREAM OF NGAWUN BRIDGE

Time interval	Left bank shift(M)	Direction	Right bank shift(M)	Direction
2001-2007	58	Left	84	Left
2007-2009	57	Left	30	Right
2009-2010	57	Left	1.65	Left
2010-2014	53	Left	87	Left
2014-2016	28	Left	57	Left

Comparison of Widths of the Ngawun River

These measurements are respective widths of the river at March and November in 2001, 2005, 2007 and 2010 .These data are measured using GIS. According to these measurements, river morphology change can be known. Ngawun Bridge (Myo Kwin) is located between Pt B and Pt C. Five places of measurements are conducted along the study river reach for twenty five seconds interval before and after construction.

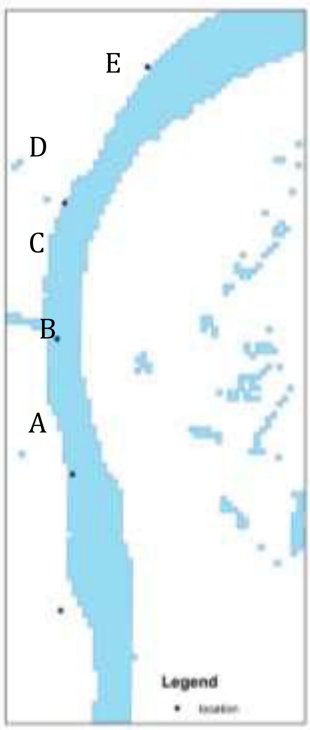


Fig.4 Location points between twenty five seconds interval

TABLE I
WIDTH OF THE NGAWUN RIVER CHANGES AT RESPECTIVE YEARS (MARCH) (METER)

Year	Location				
	Pt A (17° 42’ 5” N)	Pt B (17° 42’ 30” N)	Pt C (17° 42’ 55” N)	Pt D (17° 43’ 20” N)	Pt E (17° 43’ 45” N)
2001	120	240	150	150	300
2005	300	270	210	240	510
2007	210	240	150	180	570

2010	270	240	180	240	570
2014	167	197	111	140	507
2016	150	222	120	150	480

TABLE III
WIDTH OF THE NGAWUN RIVER CHANGES AT RESPECTIVE YEARS (NOVEMBER) (METER)

Year	Location				
	Pt A (17° 42' 5" N)	Pt B (17° 42' 30" N)	Pt C (17° 42' 55" N)	Pt D (17° 43' 20" N)	Pt E (17° 43' 45" N)
2001	460	316	434	300	510
2005	419	285	330	360	450
2007	390	300	300	330	390
2010	450	315	420	375	525
2014	180	210	140	150	509
2016	200	270	169	203	487

Bed level changes

The bed level changes are shown in Figure 5.The observed bed level data are taken from the Directorate of Water Resources and Improvement of River System (DWIR). The bed level reached about 15.9 m in 2013.

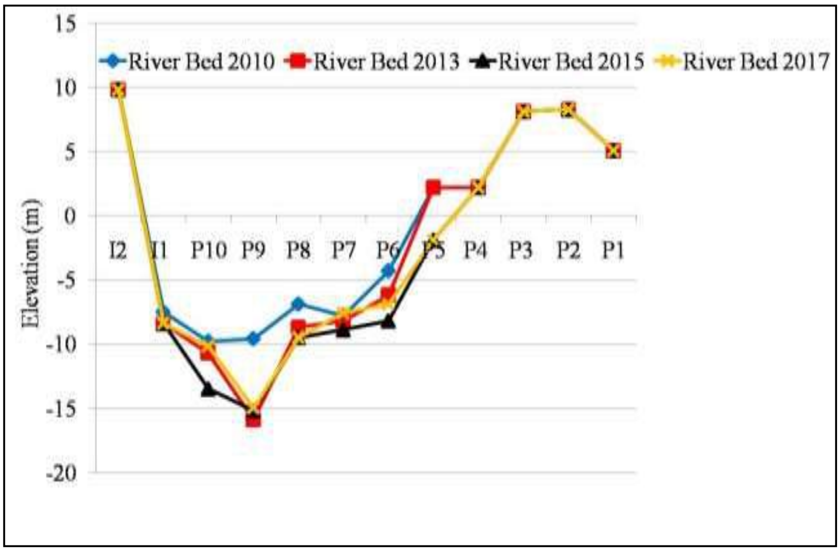


Fig.5 River Bed level changes Ngawun Bridge (Myo Kwin)

7. CONCLUSION:

The Study demonstrates river morphology change and shifting of river channel directions using GIS and GEE from medium resolution Landsat images .This type of study is obliging for further planning of river and river adjacent to settlement management an effective manner as it could be incorporated the long time changes of Ngawun river, Different amount water area identified from satellite images may have different month of imagery. River channel changes between 17° 43' 20" -17° 43' 45" North latitude, upstream of the river, river changes dramatically. In river shifting, seriously shifting can be seen between 2010-2014.River shifted 53 meter to the left and 87 meter also to the left. So, river shifted to the left more than 2009-2010.Left bank of river was eroded than right bank. Width of the river, in March 2010, at 17° 43' 45" N is 525 meter.

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