

The Effects of Water Erosion on The Eastern Bank of the White Nile at Detang Village in Upper Nile State, South Sudan.

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By: Okel Akol Ajawin, College of Education, Upper Nile University-Upper Nile State, Malakal
 Supervisor: Dr. Alamin Alawad Hag Ahmed, Faculty of Urban Sciences, AlZaim Alhari University-Khartoum-Sudan
 E-mail: Elaminhag1@gmail.com
 Tel: 0912484650
 Correspondent Author: Okel Akol Ajawim
 E-mail Address: Okelakol77@gmail.com
 Telephone No. 0961512013

Abstract:

The study dealt with the erosion of the banks of cities and villages located on the banks of the White Nile in general and the eastern bank of Ditang village in particular. As the phenomenon of water erosion, which leads to the removal of soil and eroding of the banks of cities and villages located near proximity to the water courses, therefore this study aimed at identifying the soil type of the study area, in addition to knowing the percentage and size of the area of change that occurs in the village in particular and the entire island in general, due to the erosion process, by comparing several satellite images for different years from 1973 to 2016 for a maximum period of 43 years. This study is based on the observation and indicators of the effect of the erosion process on the West Bank of the White Nile, ie, the eastern bank of Detang village. Thus, in order to achieve the objectives of the study, some of the scientific research methods were used: soil testing method, social survey method and comparative method. The study concluded that the erosion of the West Bank of the Nile at Detang was due to the interaction of several factors, including: the watercurrent of the White Nile hitting on the West Bank, the presence of a water curvation on the eastern bank of the Nile facing the land of Detang village On the West Bank of the White Nile, the dominance of the sandy loam soil in the study area, the undulated surface of the study area and the various human activities on the eastern bank of the area. The (43) year is about (15.16%) and this means that Detang village may disappear from the earth's surface in about three centuries. The convex slope (lateral erosion) On the West Bank of the White Nile at Detang village, the spread of the Nile water at the expense of the dry land on the West Bank of the Nile as a result of the acceleration of water erosion on the study area. The researcher faced several difficulties during the period of this research: Difficulty in obtaining information from the population of the study area, visiting the study area during the time of the civil war in South Sudan, lack of previous studies (secondary data) on the impact of water erosion and the factors affecting this phenomenon on the cities and villages located on the banks of the White Nile in the Upper Nile State in general and the eastern bank of Detang village on the West Bank of the White Nile in particular, lack of financial support for the study. The results recommended the installation of the bank toe and the restoration of the vegetation on the concerned bank, the treatment of human activities that complicate the problem of erosion, introducing some administrative strategies that reduce water erosion and addressing the effects of the implementation of the Jonglei Canal project.

Finally, this study could be the beginning of further studies in the field of factors affecting water erosion on the bank of the white Nile in the State of South Sudan in general and its West Bank at Detang village in particular, in addition to studies in the field of reducing the effects of water erosion on the cities and villages located On the banks of the White Nile in Upper Nile State in particular and the Republic of South Sudan in general.

Keywords: ERDAS, GIS, RS, GPS.

1.Introduction:

Detang is a village that was founded by Radh Ocollo (Odak) the second born son of Dak son of Nikango who had governed as a Collo Radh from the year 1615-1635, his father was Dak Wad Nikango and his mother was called Nidway NyaNikango Okwa. Nyimon was the first daughter of Dak wad Nikango.

The village was located on the Northern west bank of Malakal town the capital of Upper Nile State.

Detang has fallen administratively under Payam Lelo (Obwa) which is part of Malakal County and is a spiritual centre of Ocolo (Odak) wad Nikango.

Ocollo was the first Collo King to be buried amongst the previous kings, who used to disapper. Detang is the colour of a black bull that was sacrificed for the building of the village of Detang. This village was the first place where the shrine of the king/ Radh was erected.

In the present time this village has a distinguishing feature due to its physical appearance by the intensity of plane trees – *Borassus-aethiopicum* especially on its Eastern side which is considered as the most beautiful scenery of the former Republic of Sudan and the newly Republic of South Sudan. Therefore, the eroding of this bank by water that leads to the failing of these trees into the White Nile would rob this beautiful nature and expands the eastern bank of the village at the expense of the dry land.

1.2. Objectives of the Research:

The objective of the research project summarizes, what is to be achieved by the study. The objective answers main questions" what, where, why". This research aims to achieve the following objectives:

- To identify the effective factors of water erosion on the western bank of the White Nile at Detang village.
- To make available information system of water erosion factors that contributed in eroding the western bank of the White Nile at Detang village necessary for future studies.
- To find out the actual nature of the White Nile channel and its width by comparing different satellite imageries of the concern area in different years.
- To identify the general slope of the study area.
- To measure the space eroded annually by water to predict its present and future effect on the eastern bank of the village, plane trees *Borassus-aethiopicum* and to the entire study area as well, in order to find possible solution to the phenomenon.

1.3. Statement of the Research Problem:

Problem of this study is a discrepancy between what should be and what existing.

A problem, when identified for research, should be defined as far as the following issues are concerned:

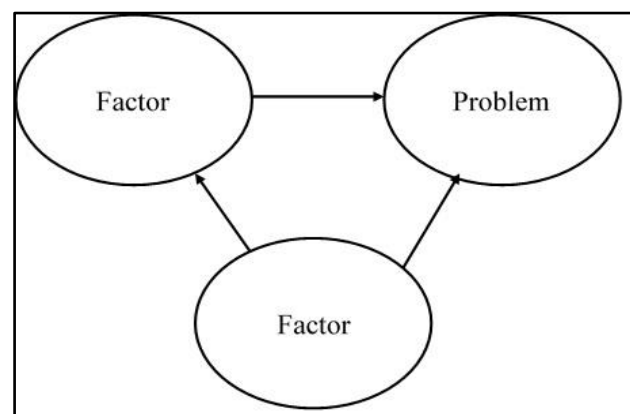
- Incidence and prevalence.
- Geographical areas affected.

- Characteristics of population groups. ²
- Probable reasons for the problem.

Accordingly, there are features of water erosion in the area in form of expanding and retrograding of the eastern bank towards the western side of the village at the expense of the land , the standing of some plane trees *Borassus aethiopicum* in the area of shallow water in the White Nile than on the land in the previous years' which resulted in their falling and reduction of their numbers, and small distance between the residential area and eastern bank of the village showed of the ongoing erosion on the concerned bank

This phenomenon whose present and future danger has not been acknowledged by the natives and the government of the Upper Nile State is a strong reason behind this study to access and fine out its danger in order to find real solution to preserve these trees which are considered as one of the most beautiful and charm of the Republic of South Sudan, see Chart No. (1)

Chart (1): Elements of the Problem Analysis Diagram (PAD)



Source: Dr.Abdel Rahim Mohammed Babiker(NRU).

1.4. Research Questions:

The research question is the central issue being addressed in the study and is often phrased in the language of theory.

There are five questions for this research as follow:

- Why the western bank of the White Nile at Detang village was being eroded?
- What are the effective factors of water erosion that caused retrograding of the

western bank of the White Nile at the expense of the eastern side of Detang village?

- What was the actual width of the White Nile channel at Detang village now and in the previous years?
- What are the present and future effects of water erosion on the western bank of the White Nile, plane trees – *Borasusaethiopum* and to the entire study area as well?
- How could water erosion be controlled?

2. Background of the Study Area:

When Makal country was established in 2004, the country split letter into a total of 6 payams. These payams are as follow:

- PayamOgod.
- PayamMakal.
- PayamLelo.
- The Northern sector.
- The Central sector.
- The Southern, respectively.

Detang village or DetangBoma is an island which is located between stream Lol from west and the White Nile from the east. On the other hand, the village is situated on the North- West bank of Malakal town the capital of Upper Nile State.

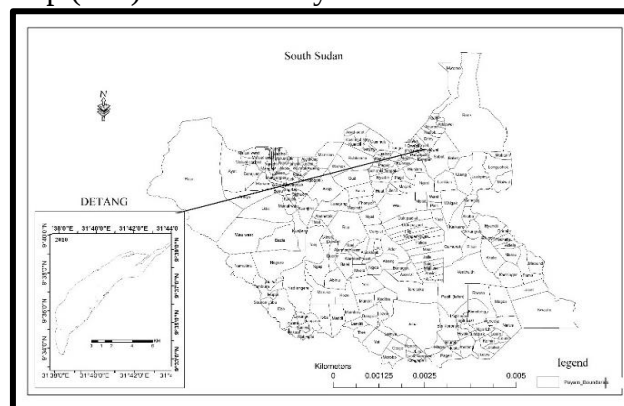
2.1. The Name Meaning:

Detang is the colour of a black ball that was sacrificed for the building of the village of Detang. This village was the first place where the shrine of the king Rath was erected.

2.2. Location of Detang Village:

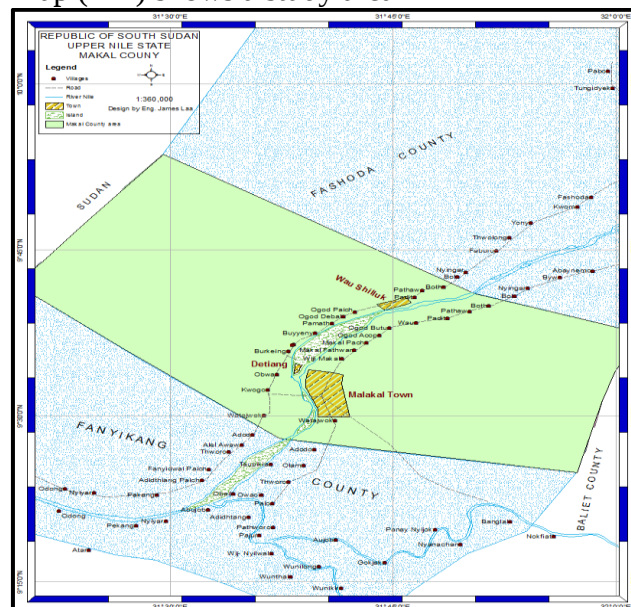
Detang village (Boma) is located in the Upper Nile State of the Republic of South Sudan on the western bank of the White Nile. The area is located between Latitude lines ($9^{\circ} 33' N$ and $9^{\circ} 38' 43'' N$) and longitude lines ($31^{\circ} 38' 06''$ and $31^{\circ} 42' 51'' E$). The area is at 398 meters above the sea level, see Map No. (1-A&B).

Map (1-A) shows a study area



Source: Processed by the researcher 2019

Map (1-B) shows a study area



Source: James Laa, 2016.

Generally, the area is about (31) kms long in approximate (North South direction) including the Loll mouth about (4)kms wide.

It extends from WijiMakal in the North up to WijiAngham, the confluence of Loll and the White Nile in the South and from the residential areas on the eastern bank of the White Nile in the east up to Bukiany in the west on the western bank of the White Nile, while on the eastern bank of it extends from ThworoBouny in the North up to Lwakat north.

2.3. Population of the Study Area:

Collo is the most predominant tribe inhabiting the area; they work mainly in trade, trade exchange, animal rearing Nile transport, fisheries and vast agricultural activities.

2.4. Present Land Use Management and Human Activities:

Most people of this village practice traditional rainfall agriculture. The most important crops are Dura, sesame and maize. In addition they grow different kinds of vegetables throughout the year. Few vegetables plots are also noted within Detang village that are irrigated by a hand operated water lifting device (Pumping) directly from the White Nile with five inches diameter pumps. (a)

All the agricultural activities within Detang village are carried out on the western and eastern bank of the White Nile on the western bank of the (b) White Nile, the agricultural activities are carried out on the western bank of Khor Loll known as Abai area where the most wide crop grown such as (c) "Dura" are regularly cultivated. Whereas on the eastern bank of the White Nile, the agricultural activities are being carried out in the area known (d) as WijKiir (the bank of the Nile) in which the important crops such as Maize (Indian corn) and vegetables are grown. (e)

It is worth mentioning that Detang village is famous for the intensity of palm trees (Dolieb trees) where its natives depend on their fruits (f) (Tug) as an economic resource, especially during March and June every year.

Moreover, the agricultural activities of Detang village is destined almost exclusively for self-consumption and the production for the market is practically little, therefore, the village depends on Malakal town to provide the population's demands for food products.

Despite impressive achievements in traditional and mechanized agriculture, most wealth in Detang village is in livestock holding and fisheries.

3. Research Methodology:

3.1. The Materials of the Research:

The materials used in this research work consist at most of type of soil of the area, remote sensing data (satellite imageries of different year for the period of 1973 up to 2016), hardware, software and global position system.

3.1.a. Soil Type of the Study Area:

The method of soil testing was applied in the field area where the type of soil of the concerned was found to be the sandy loam soil (20% clay, 30% silt, 50% sand), occupying three

quarters (3/4) of the entire area especially the central and the northern parts, while the southern part is covered by clay soil, this proves what is shown by the soil map of southern Sudan, that the island is a muddy and sedimentary area that has been deposited during successive geological times.

3.1.b. Satellite Imageries of the Study Area:

A number of six satellite imageries from Landsat which cover the study area were used in this study

Landsat image, thematic mapper (MSS), 3 spectral bands (4, 5, 7) acquired in November 1973.

Landsat image, thematic mapper TM, digital format, 7 spectral bands, path 173 and row 53, acquired in 1980.

Landsat image, thematic mapper TM, digital format, 7 spectral bands, path 173 and row 53, acquired in 1990.

Landsat image, thematic mapper TM digital format, 7 spectral bands, path 173 and row 53, acquired in 2000.

Landsat image, thematic mapper TM, digital format, 7 spectral bands path 173 and row 53, acquired 2010.

LandsatOLI-TIRS image, thematic mapper TM, digital format, 7 spectral bands, path 173 and row 53, acquired 2016. see table No. (1).

The researcher applied the techniques of remote sensing and geographic information systems in the process of analyzing the changes that took place on the island during the period from 1973 to 2016 in order to analyze the processes exposed to the eastern parts of the island through the process of monitoring and follow-through satellite images of the US satellite series. Landsat Shown in the table.

Table (1) The most important coverage used in the study

Date	Satellite. image	Path	Row
1973	LANDSAT.MSS	173	53
1980	LANDSAT.TM	173	53
1990	LANDSAT.TM	173	53
2000	LANDSAT.TM	173	53
2010	LANDSAT.TM	173	53
2016	LANDSAT.OLI-TIRS	173	53

Source: USGS Geological Survey of America

The process of analysis of satellite data revealed the impact of the survey on the island and the analysis of the area and places affected by the erosion and seismic processes and observed changes that cannot be detected during the course of the year. But south of the study area are drifting vertically towards the island, while the island is a muddy and sedimentary area that has been deposited during successive geological times. However, the area where the currents collide has not been affected directly, but may also affect the length of the island's beaches.

3.2. The Methods:

The methods which were used in this study are as follow:

3.2.a. The Field Work Techniques:

Techniques used for the field work of this study were as follow:

- Testing of soil sample in the study area (Detang Village).
- Interviewing Techniques.
- Observation Technique.

▪ Testing of Soil Samples in the Study Area:

As the research topic deals with the effects of water erosion on the western bank of the White Nile of Detang Village; the main objective of this research which is the identifying the effective factors of water erosion on the above mentioned bank of the village, being the soil type of area is one of the main factor that accelerate the action of water erosion, therefore, the method of field testing of soil was done in order to identify the soil type of the study area.

▪ Interviewing Techniques:

For sample collection the probability sample methods were used namely the simple random sampling where all units have the same chance of being selected. Accordingly, for population of Detang village a number of 50 people were selected randomly to represent the whole population group of the area.

Formal interview with some villagers, intellectuals and chiefs of Detang village was conducted and data concerning the geographic, the soil type of the area and ongoing water erosion on some area on the eastern bank of the village was

also obtained. Moreover, the informal interviews⁵ with some natives were also carried out.

Here are the names of interviewee:

- Jachinto Tegijwok Wanth-5/6/2015
- Dr. Owet Ochwang Ongwany-10/9/2016
- Albino Obec Ongwany-13/3/2016
- Twang Aban=15/5/2016
- Benjamin Bol-27/12/2017
- Peter Lual Ongwany-12/1/2018
- James Tipo Akol Ajawin-12/1/2018
- Samuel Oliver Samsame-20/11/2018
- Dieng Adiang-22/12/2018
- Albino Oyath-31/4/2018.
- **Observation Technique:**

The observations in the area of study were as follow:

- The expanding of the eastern bank of the village towards the western side of the village at the expense of the land. stream, see plate No. (1)

Plate No. (1)



Source: by the researcher 2016

- The standing of some plane trees – *Borassus-aethiopum* in the area of shallow water of the White Nile than on the land in the previous years. stream, see plate No. (2)

Plate No. (2)



Source: By the Researcher

- The small distance between the residential areas and the channel (stream) of the White Nile
- Failing of the *Borassus-aethiopum* into the White Nile stream, see plate No.(3)
- Plate No. (3)



Source: by the researcher 2016

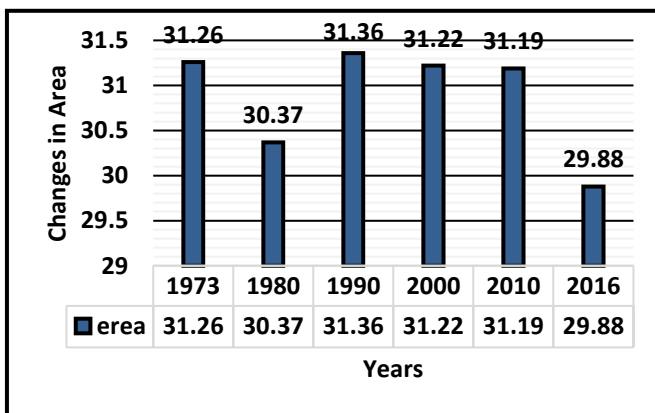
4.Data Analysis Techniques:

The statistical package for social science (SPSS), Microsoft excel 2007, Google earth and ARC GIS 16.2.2. were used for analysis of data which are collected about the study area using the above mentioned software to represented in the following shapes.

4.1: The Charts:

There were drawn to illustrate the data on the following:

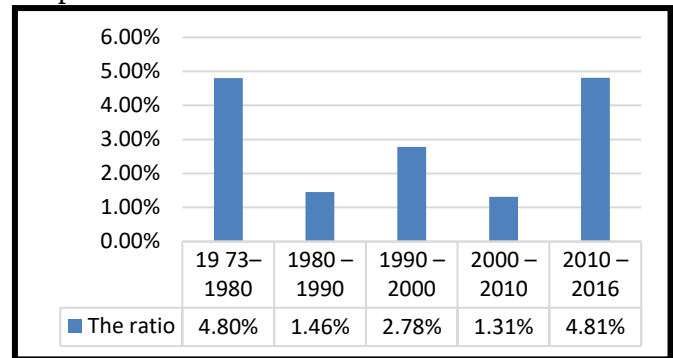
- The general changes (in kilometers squares) on the study area during the period 1973 -2016.



Source: By the Researcher

- The ratio of the affected area (in percentage) during the period 1973-2016 sees chart No. (2).

Chart (2) The Ratio of the Affected Areas during the period 1973-2016

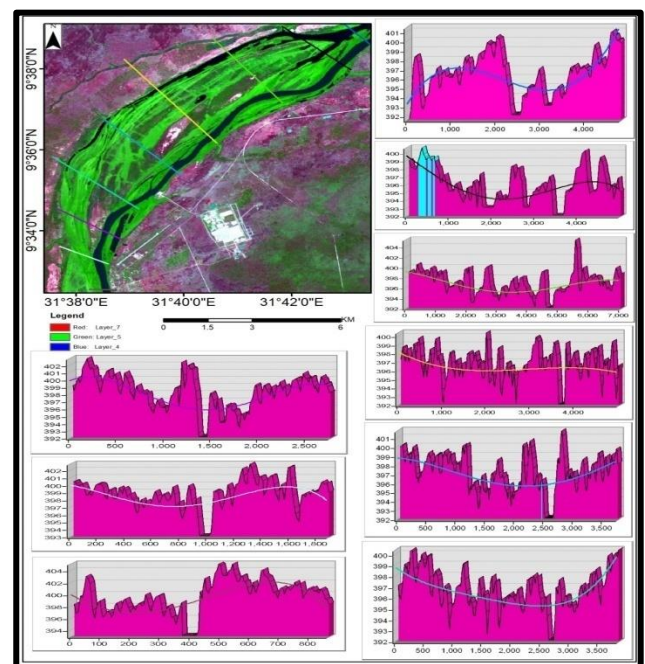


Source: by the researcher 2016

4.2. The Graphs:

These were drawn to illustrate the followings:

- The contour map of the study area
- The Cross-Section of the Study Area ,see Graph No.(1)



Source: By the Researcher According to Land sat image, thematic mapper TM, digital formed, 7 spectral bands path 173 and row 53, acquired 2010.

5.Results and Discussion:

The basis aim of this research was to identify the effects and the effective factors of water erosion on the western bank of the White Nile at Detang village in Upper Nile state. This was done by comparing numbers of satellite imageries of the area for different years, 1973,

1980, 1990, 2000, 2010 and 2016, in order to know the change development that took place on the Island during the period from 1973 to 2016 in general and the major factors of water erosion within the study area in particular.

As a result, six satellite imageries as the above mentioning years (1973-2016) were gathered, compared and analyzed through different programs such as ARC map and ERDAS imageEn2015 where the result obtained was through the following procedures:

5.1. Comparing of maps which were produces from satellite imageries during the period from 1973 to 2016:

It is worth mentioning that there were software programs used in the processes of comparing of satellite imageries of the concerned areas such as (ARCMAP) in which the data was inserted, corrected and processes according to the objectives of the study and ERDAS image in 2015 program through which the above mentioned processes was done. In addition, that some spatial improvement, spectral, distinctiveness, special equation was used for separating water from the land to know the effect of water erosion on the eastern bank of Detang Village as a study area by comparing a number of satellite imageries of different years from 1973 to 2016. Thus, the year 1973, was chosen as the basic period of the comparison process because there was no satellite imagery for that period. Also, there was no change in the area of the Island and its eastern bank during that period.

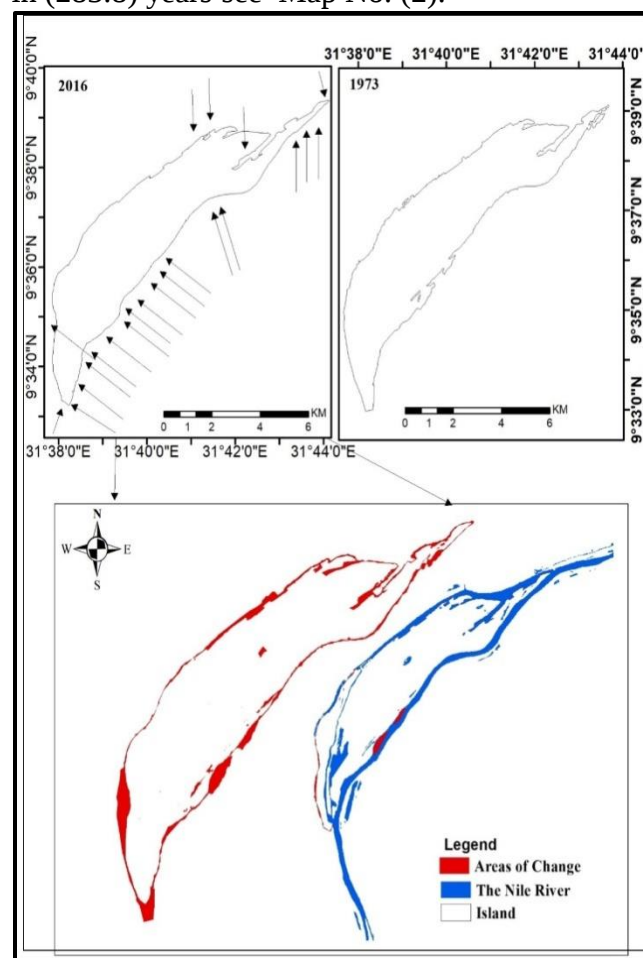
In order to calculate the change in the area of the Island and its percentage, the satellite images were compared and the results were as follow:

Between 1973 and 1980, the amount of change on the Island in this period was estimated at 1.46km² and by 4.80%. The effect of water erosion was clear in the South-eastern part of the Island, especially in the area where clay soil predominates in the area of dense plane trees. Borasus-aethiopum are standing in this part of the Island,

In the period between 1980 and 1990, the amount of change in the Island amounted to about 0.46km² and 1.46% where the effect of water erosion was slight along its eastern bank, starting from the south; the middle and the northern part

respectively. The period between 1990 and 2000, showed a remarkable increase in the process of ongoing erosion amounted to 0.87km² and by 2.87% of the total area of the Island, where the effect was on the south east and north – east of the eastern banks of the study area. The period from 2000 to 2010 was calculated at 0.41km² and by 1.31% of the total area of the Island. This is the period during which the water has been shown to play an active role in the process of erosion on the banks of the Island in general and the western bank of the White Nile at Detang village in particular area.

Finally, the period between 2010 and 2016, is the period in which the erosion strongly affected the Island for half a century, with a total impact on the concerned bank about 1.44km² of the total area. Base on the affected area within Period of (1973-2016) 43 years, the total percentage was (15.16%), which means that the entire island would disappear in (283.8) years see Map No. (2).



Source: Processed by the researcher by using (ARCMAP10.2.2)-2019

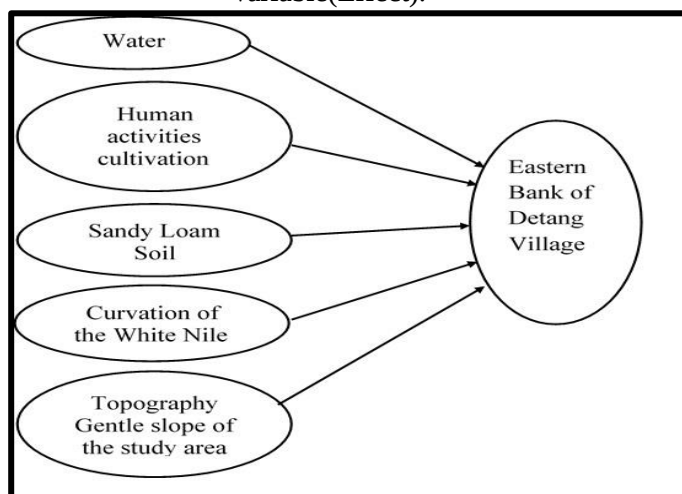
5.2. The Effective Factors of Water Erosion on the Eastern Bank of Detang Village:

Since the identification of the factors affecting the erosion of the eastern bank of Detang village of the western banks of the White Nile as one of the main objectives of this study, the factors has been identified as follow:

- The Curvation of the White Nile Channel within the study area.
- The Sandy Loam Soil
- The General Slope of the Study Area
- Human Activities

Research Model: see Chart (4)

Chart (4): Independent Variable(Cause) and Dependent variable(Effect).



Source: The Researcher 2019

6.Summary and Conclusion:

This study was conducted on the effects of water erosion on the western bank of the White Nile at Detang village in Upper Nile state, during the period 1973 and 2016.

There are two main objectives: first, to identify the effective factors of water erosion on the western bank of the measure the space eroded annually by water to predict its present and future effect on the eastern bank of the village, plane trees (Dolieb) – Borasasaethiopum and to the entire study area as well.

The summary and conclusion that could be drawn from this study were as follows:

- The processes of analysis of satellite data of the years 1973-2016 revealed the impact of the survey on the Island and the analysis of the area and places affected by the erosion and seismic processes and observed changes that cannot be detected during the course of the

year but can be observed cover time. Therefore, the worth-mentioning findings of those analysis, is the fluctuation and variation in the size of the affected area (in percentage), and the amount of changes (in kilometers squares) in the study area during the period of 1973 and 2016. Accordingly, the amount a change in the Island between the period 1973 was estimated at 31.26 kilometers square (km²), where the affected area by water erosion was 4.80% of the total area of the Island. Even though, the amount of change decreased in 2016, estimated at 29.88km², the percentage of the affected in the same year, showed a remarkable increase in the area amounted to 4.81%.

- In conclusion, the affected areas by erosion especially the western bank of the White Nile at Detang village was quite clear in form of expanding and retrograding of the concerned bank towards the eastern part of the study area, narrowing the distance land between the residential area and the White Nile course, which is an indicator of the continuous eroding of the above mentioned bank by the effective water erosion. This phenomenon if not control, it could lead to the wearing a way, drawing and disappearance of the study area from the land in
- The curvation of the White Nile channel at its eastern bank, known locally as WijKiir in which the high volume of water flows with its strong and intensity when collides on this eastern bank its water current (velocity) drifts vertically towards the western bank. This action accelerates the processes of eroding, transporting and depositing the soil of the concerned bank of the White Nile. The effects of water erosion on the eastern bank of the Island have been traced by the following successive phases.
- i-The spreading of White's Nile water into the area of plane trees (Dolieb) Borasusaethiopum.
- Standing of Borasusaethiopum on the area of shallow water of the White Nile.
- The detachment and removal of soil materials from the land and around the roots of trees.
- Failing of Dolieb trees Borasusaethiopum and slumping of the bank into the flowing water of

White Nile. As a result of this the eastern bank of the study area was being eroded and began to bend or meander, as the stream bends become longer and more sharply curved, more soil is eroded from the western bank transported and be deposited on the area of shallow water resulting in the emergence of an Island in the north eastern side of the study area.

- The sandy loam soil as the soil type of the study area got saturated when the White Nile water flooded over the low lying bank in the rainy season. This type of soil with its common characteristics allowed the soil surface to be easily eroded, transported then deposited on the Island located in the north – eastern side of the area, whose size is gradually increasing as a result of continuous eroding of the concerned bank of Detang Island by water erosion.
- The undulated surface of the study area, sloping northwards in accordance to the general slope of the continent, where the study area (Detang) village appeared in the cross - section as a concave slope. This would cause an increase in the slope length that increases the surface area for water collection. On the other land, the western bank of the White Nile at Detang village appeared in the cross-section as a convex slope, which showed the increase in the degree of steepness, coupled with the existence of sandy loam soil in the area, this strengthens the surface run-off, loss of soil materials and nutrients, organic matter, calcium and seeds, moving them into the White Nile stream.
- The above mentioned processes increase water erosive energy on its western bank at Detang village resulting in the formation the concave area on the concerned bank.
- Human activities being practiced particularly on the western bank of the White Nile, such as pasture and livestock rearing, cattle grazing, cultivation of ground nuts, vegetable and fruits of different kinds. These practices could create surface and sub-surface run-off that eroded great quantity of soil and moved it into the White Nile water where it is transported, deposited further north of the study area.

- Moreover, lack of implementation of agro rotation system on the bank, where the land is left bare for the period of four hottest months of the year. This practice exposed the soil to sun rays as well as the prevailing winds that blew into the Island from different directions, those winds as agents of erosion in the dry season, blown away soil particles into the White Nile course, resulting in the denudation or lowering the level of the eastern bank of the Island.

Finally, the output of water erosion on the above mentioned bank led to the expanding of the White Nile channel at the expense of the land on the western bank of the White Nile at Detang village.

7.Recommendations

Based on the previous discussions and findings of the study, the following recommendations are seen necessary to be forwarded:

- In the case of the expanding and retrograding of the western bank of the White Nile at Detang village towards its eastern part at the expense of the land, causing to the failing of Dolieb trees – *Borassiaaethiopum* into the White's Nile water as a result and the effect of the ongoing water erosion on the concerned bank. It is suggested that the introduction of management strategies that minimize water erosion is essential and necessary such as the following:
- Build water bars, to support structure failure.
- Vegetation waterways are built to protect soil against the erosive forces of concentrated run off from sloping lands. They absorb the destructive energy which causes channel erosion and gully formation.
- Installing a sub-surface drain system to intercept the drainage before it reaches the stream.
- Planting of grasses on a stream bank to reinforce a bare stream bank.
- Placement of woody plant and tree cutting on a graded bank to grow and stabilize the bank by the formation of roots and above ground growth.
- Logs are placed in the stream and held in place by boulders. The root wads are than placed around the boulders to slow the flow of the

stream, protect the bank and provide habitat for fish and wildlife

- Concerning the existence of the curvation of the White Nile channel on its eastern bank of Detang village that increases the force of the water flowing against the western bank causes the removal soil particle, slumping and failing of the bank into the flowing water of the White Nile stream. Stabilizing the bank toe, restoring bank vegetation and layering of live branch cuttings with compacted soil to fill small holes are strongly recommended.
- Regarding the existence of the sandy loam soil especially on the eastern bank of the White Nile. It is suggested that the application of growing plants or crop residue (vegetation cover) in the study area, be introduced in order to provide protective cover on the land and prevent soil erosion by agents of erosion (Water, raindrops and the wind).
- In the case of human activities mainly agricultural activities, livestock rears and cattle grazing on the concerned bank. The following practices should be fully applied:
 - The agro-rotation system.
 - The reducing of the stream bank erosion through conservation measures near the stream by using the following practices:
 - Farm no close than 75-90 feet from the stream bank and establish permanent type vegetation in this area identities as buffer strip.
 - Do not place excessive weight on the top of the bank in the 15-foot-wide strip nearest the stream. Do not make this a place for dispassion of derbies from the surrounding land or as a travel land for vehicles or farm equipment.
 - Restrict or eliminate livestock access to the stream bank or buffer zone. If possible, use off stream watering sources to provide water to livestock. If this is not possible, restrict watering to specific locations where adequate stream bank protection exists.
 - Remove fallen trees or other debris from the stream it debris is causing bank erosion problems. However, because trees often improve aquatic habitat condition in stream, removal should be avoided when possible.

- Regarding the altitude of Detang village that is 398 meters above the sea-level. It could be strongly stated that, the altering of the White Nile course by the Jonglei canal as a designed hydro-construction project. The completion of this project could lead to a catastrophe as it would loss more than two million south Sudanese lives and drown of the study area.
- In conclusion, the ongoing erosion on the Eastern bank of the White Nile at Detang village as part of the entire island, if not control it could lead to fully disappearance of the study area from earth's surface in 283.8 years' time.

References:

Books:

- Alan Strahler-Cambridge, Massachusetts & Arthur Strahler-Santa Barbara, California, July 1, 1996, Physical Geography (Science and Systems of the Human Environment).
- Dr. Daniel Thabo Nyibong, without date, The History Of the Collo People of the Sudan.
- Dr. Lam Akol Ajawin, January 2016, Collo boundary Dispute.
- USDA, Natural Resources Conservation Service May 2001.

Reports and bulletins:

- Dr. Abdel Rahim Mohammed Babiker – Assistant Professor – national Ribat University, Research methodology Research proposal – A simplified manual – Sudan.
- Kal Kaska County Community Center 9/3/2003:

Internet:

- <https://www.google.com/search?hl=cycling+of+water+on+the+continents>
- <https://www.google.com/search?q=precipitation&source>
- <https://www.google.com/search?q=zones+of+subsurface+water&source>

interviews:

- The information is taken from the following; -
- Jachinto Tegijwok Wanth-5/6/2015
- Dr. Owet Ochwang Ongwany-10/3/2016
- Albino Obec Ongwany-10/9/2016
- Twang Aban-15/12/2016
- Benjamin Bol-27/12/2017.