

Geomorphology of the Blue Nile

A Study Using Remote Sensing

Osman A. Rahim Osman

1. Introduction

The mapping of the Blue Nile and its palaeochannels was performed using a mosaic of two satellite images, raw 50 paths 185 and 186 of December 1975, starting from about 20 Km north of the Sinnar dam in the south east to about 10 Km north of El Messed. This Nile system could be considered as a main stream with some subsequent streams like the Dinder and Rahad rivers, which come from the same source and join the Blue Nile from the east.

Geomorphologically the mapped Blue Nile could be classified as a meandering river of three different genetic ages, the old stage from the south eastern part of the study area (A), the mature stage in between (B), and the young stage in the northern part of the study area (C).

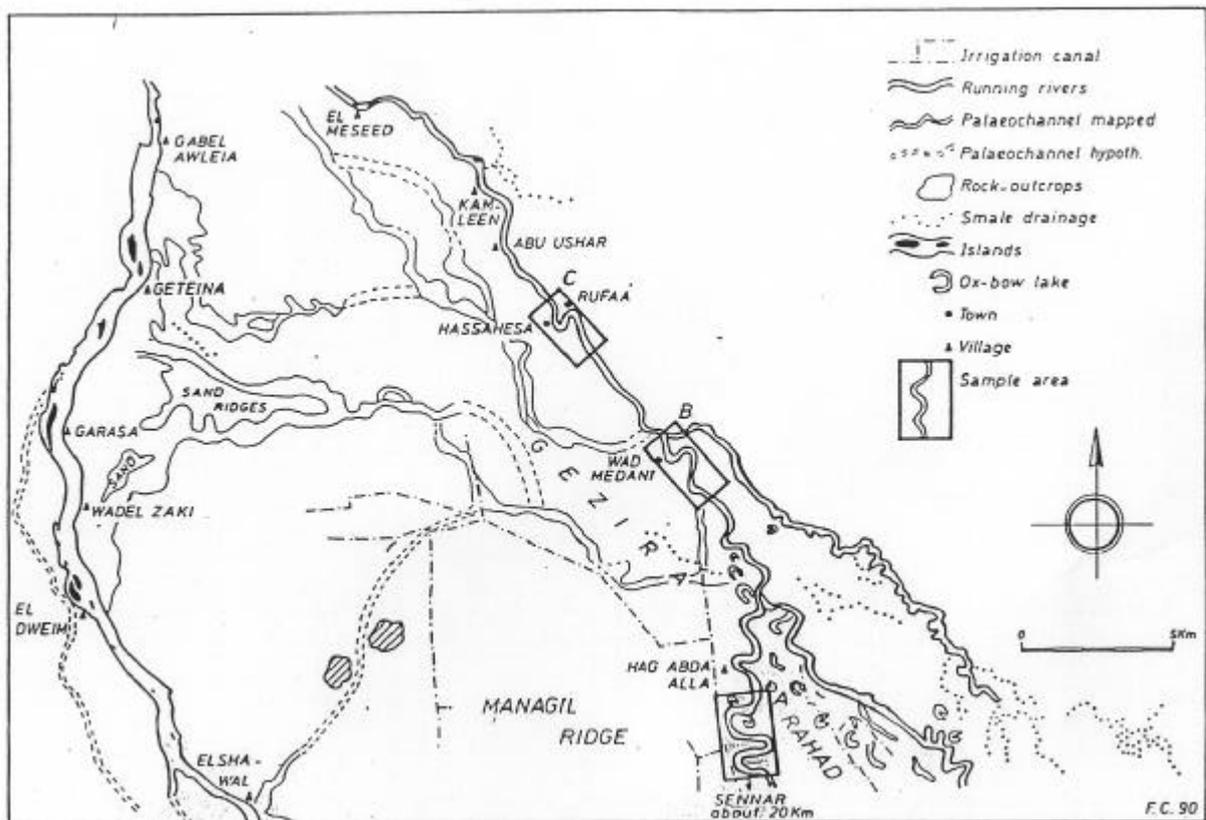


Figure 1. Location of the Sample Sites.

2. Objectives

- To prove that remote sensing is an efficient tool to map the palaeochannels of the rivers.
- To map the palaeochannels of the Blue Nile on the Gazira area, where it is now covered by dense cultivation.
- To prove that the Blue Nile is a meandering channel of three genetic ages.

3. Materials and Methods

Materials used were satellite images, mirror stereoscopes, binoculars, tracing paper, drawing pens and light tables.

The methodology used was the element interpretation used by ITC Enschede, the Netherlands. For calculating the sinuosity index, the formula of Brice (1964) was used.

$$SI = \frac{\text{Length of Channel}}{\text{Length of Meander Belt Axis}}$$

Field checks were done for about two months to check the ground truth along the Blue Nile.

4. Results

Brice (1964) used the sinuosity index to separate straight from sinuous and meandering channels. If SI is less than 1.05, the canal is straight, if SI is between 1.05 - 1.5 it is sinuous and if SI is higher than 1.5 the pattern is meandering.

SI = 1.05	Straight
1.05 – 1.5	Sinuous
1.5	Meandering

The equation suggested by Brice (1964) was applied to a study of the Blue Nile area in the central plain of The Sudan.

For map (A) the calculated sinuosity is:	44.7 / 20.2 = 2.21 Meander
For map (B) the calculated sinuosity is:	29.8 / 20.4 = 1.44 Sinuous.
For map (C) the calculated sinuosity is:	27.4 / 20.6 = 1.34 Sinuous.

5. Discussion

Geomorphologic interpretation of aerial photographs can be direct interpretation because of the visibility of the objects. On satellite images one has to use other criteria for the identification of landforms. There is generally less deduction involved than with most other kinds of interpretation and a high degree of reliability may thus be obtained. The applicability of the technology in geomorphological survey and mapping is obvious; detailed maps of scales to 1:50,000 can be made with the aid of large to medium scale aerial photographs (Verstappen, 1977).

An accurate, detailed and quick representation of the relief form is then insured and investigations can be carried-out even if no reliable topographical maps of the area exists.

Small-scale imagery such as that obtained from orbiting spacecraft can contribute to geomorphologic reconnaissance mapping even at scales of 1: 1,000,000 and less.

Rivers are dynamic and important parts of the physical environment. They are essential agents in erosion and transportation. In performing their erosional and transportational work, rivers develop a wide range of network and channel forms.

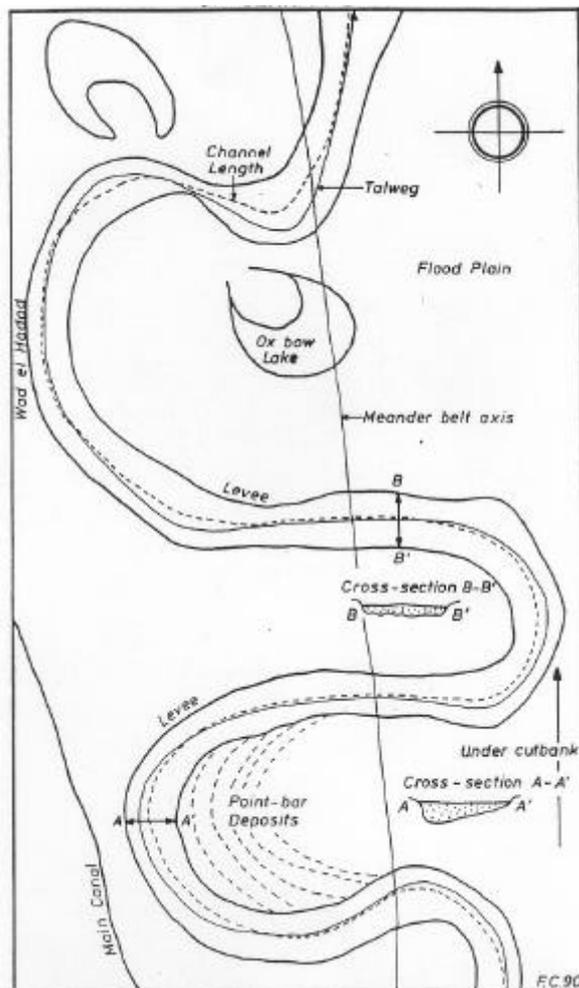
6. Landform of the Study Area

The study area is characterized by fluvial landforms. The fluvial systems have the energy to erode and transport large quantities of soil debris, sort the materials and eventually deposit them.

The area features a typical fluvial landscape with flood plain, delta and other alluvial landforms.

Flood plains are formed when sediments carried by the Blue Nile and its tributaries were deposited long ago during flood periods in the Gazira area when stream velocity was low.

The alluvial landforms seem to have formed when stream systems originating in the mountains washed down large quantities of sediments onto the adjacent plains. The Blue Nile originates in the Ethiopian highlands and washed down large amount of sediments on the Gazira plain.



More meanders with clear ox-bow lakes. We can hardly see any Island

Figure 2. Map A. Part of the present old Blue Nile, North of the Sennar Dam

The channel length i.e. the line running at the middle of the stream, is about 44.7 Km for this part of the sample area. It is the longest channel length of the tree samples because it has more meanders than the other two samples. The talweg length of part (A) is measured as 46 Km and is the longest

6.1 Drainage

The drainage system in the study area is a meandering system. The texture density is medium from latitude $14^{\circ} 10'$ N down to Khartoum.

6.2 The Old Stage Map (A)

This map represents a part of the old Blue Nile; five meanders could be observed on this part. The straight-line distance from the southern end to the northern point is calculated as 20 Km. Within these 20 Km, the Blue Nile is meandering continuously, forming some point bars and ox-bow lakes. These point bars and oxbow lakes are formed by the helical flow that localizes erosion on the outside bends of the meanders and deposits on the inside bends where they form the point bars. There are two clear oxbow lakes on the sample map.

The meander wave length ranges from about 8 Km to 10 Km. The meander width ranges from about 8.5 Km to 10 Km. The surface width dimensions ranges from 800 m to 1400m (over a length of about 240 Km).

The channel length i.e. the line running at the middle of the stream, is about 44.7 Km for this part of the sample area. It is the longest channel length of the tree samples because it has more meanders than the other two samples. The talweg length of part (A) is measured as 46 Km and is the longest

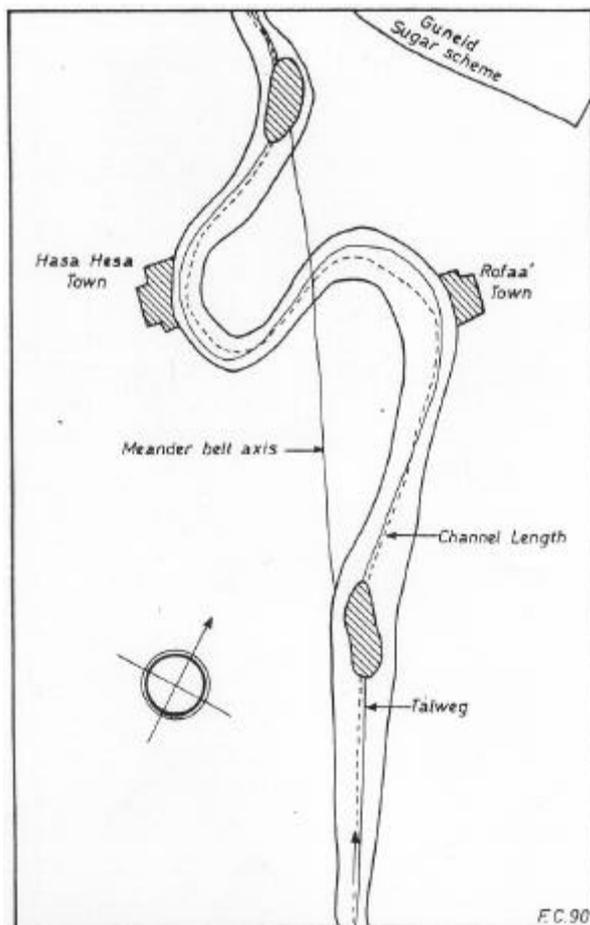
talweg of the tree samples. The meander belt axis of this site is 20.2 Km, this measurement and the length of the channel are used in this study to measure the sinuosity index (SI) using the formula of Brice (1964):

$$SI = \frac{\text{Length of Channel}}{\text{Length of Meander Belt Axis}}$$

No islands could be observed in this portion of the Blue Nile.

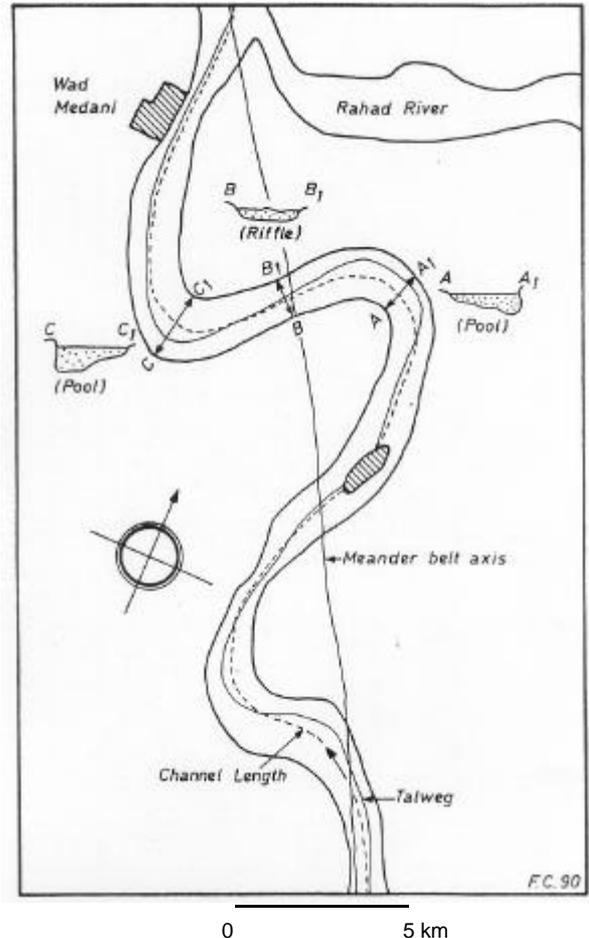
6.3 The Mature Stage Map (B)

Map (B) represents the mature part of the Blue Nile mapped from the satellite images. This part is sinuous, with less meanders than part (A). The straight-line distance of this map is also 20 Km. No oxbow lakes could be observed along this channel and the meanders are smaller. The meander wave length is about 7.5 Km. The meander width is



0 5 km
From Wad Medani to Khartoum, only one meander and slight bend. Otherwise almost straight

Figure 4. Map C. Part of the youth part of the Blue Nile



0 5 km
Less meanders and only one island was observed. The cross-sections A-A1, B-B1 and C-C1 show the approximate depth of two opposite banks. A-A1 and C-C1 are pools; B-B1 is a riffle

Figure 3. Map B. Part of the mature Blue Nile, South of Wad Medani town

about half of that on map (A): only 5 Km. The amplitude is 4.5 Km which is also half of the old stage meanders. The surface width ranges between 400 meters and 1500 meters for the wide part of the map (B). The meander belt is calculated as 120 Km².

The channel length is about 29.8 Km, it is less than on map (A) and greater than on map (C). The talweg is also greater than (C) and lower than (A): it is 31.6 Km. The meander belt axis is 20.4 Km. This belt axis and the length of the channel are used for calculation of (SI). Only one island could be observed and Rahad river is joining from the eastern side.

6.4 The Young Stage Map (C)

Map (C) represents a sample of the young part of the Blue Nile mapped from the satellite image. It starts 15 Km south of Hasaheisa town. The only meander along the young portion of the Blue Nile is part of the left bank and area Rufaa town on the right bank of the Blue Nile. The straight line distance of this part, from south to north, is the same as (A) and (B): 20 Km. The meander wavelength is 4.5 Km just more than half of the mature map (B) meander wavelength. The meander width is 5 Km the same as the width of the mature part. The amplitude is 4.5 Km, the same as that of the mature part.

The surface width ranges from 500 meters to 1400 meters. The meander belt is calculated to be 100 Km less than samples (A) and (B). The talweg is 29.6 Km.

The channel length is 27.4 Km, the smallest reading of the tree samples. The meander belt axis is 20.4 Km. The sinuosity index is calculated from the channel length and the meander belt axis. There are two islands observed.

The channel pattern or map view of the river is usually considered as straight and meander, which may be called sinuous.

7. Conclusion and recommendation

The study showed that remote sensing is a useful tool for mapping remote areas as its synoptic view can show the geological phenomena. The meander frequency is not systematic, nor is the meander wavelength, the meander width and amplitude are sometimes very variable even within the same stage of the channel. The Blue Nile study showed that it is a meandering.

Further research work with carbon age (C14) is needed to find out the real dates of the three different areas. Remnants from the three stages are needed for this type of work.

8. References

- Brice, (1964); Equation of sinuosity index: length of channel over length of the meander belt axis.
- Leopold, L. B. and Wolman, M. G. (1957); River channels patterns; braided, meandering and straight; U. S. Geol. Surv. Prof. Pap. 282-B.
- Osman, A/R. O. (1990), The study of the palaeochannels of the Blue Nile in the Gazira plain. pp 416. Gent; Rijksuniversiteit- ITC for soil scientists Ph. D. Thesis.
- Verstappen, H. T. H. (1977) Remote sensing in geomorphology. Pp 214. Elsevier scientific publ. Company Amsterdam.