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A Simulation Model for Flooded Areas of the River Nile Using Remote Sensing and GIS

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Abstract

Sudan is a large country and the Nile, which is one of the most remarkable and the second longest river in the world, runs a long distance from south of the country to the north.

The Nile is known for its marked seasonal and manual variations. The variation in discharge is illustrated by the fact that more than 80% of its manual flow occurs from August to October. It is interesting to note that manual discharge of the Nile for the year 1913-1914 was 41 milliard cubic meters as compared to 151 milliard cubic meters in 1878-1879.

Due to the history of the Nile in the Sudan, many surrounding areas were damaged during periods of floods, causing many economical problems for the inhabitants of the flood plains.

This study for the high discharge across the Nile and its effects to the surrounding areas according to the topography.

The study was carried for the upper reach of Dongola station, where continuous record for the period 1960-1990 will be used together with the topography of the area.

Remote sensing and GIS some techniques had been applied.

The results produced different maps showing the flooded areas according to the hazards of flood wave.

These results will help the planner and decision makers to take the proper measures, which will alleviate the continuous disasters of floods and relieved loss in life and property.

Introduction

The world to-day witnesses of a tremendous increase in population and a genuine effort to raise the standard of living of mankind at large. The utilization of water resources constitutes an important step towards the realization of economic prosperity as rivers have tremendous potential for agricultural development, generation of hydro-power, domestic use of water, industrial uses and fisheries.

In order to achieve these objectives it is indeed necessary to carry out conservation and control works. Water is a valuable natural commodity similar to any other natural commodities except that it has a characteristic of its own. Water flowing in rivers if not utilized today, will be lost into the seas without recovering its value again.

Hydrology of the Nile

Sudan is the largest country in Africa with a total area of approximately 2.5 million square kilometre, it is located in between the Ethiopian and Equatorial plateau, thus it is an important catchment areas for rivers and streams flowing towards it as shown in Fig.(1). The rich network of rivers and seasonal streams which is the characteristic of Sudan topography, together with wide range of rainfall that extends from 20mm in the north up to 2000 mm/year in the extreme south western part represents a great water resources potentiality. The River Nile and its tributaries as shown in Fig.(2) display the most prominent physical feature of the country. The Nile

Fig (1)

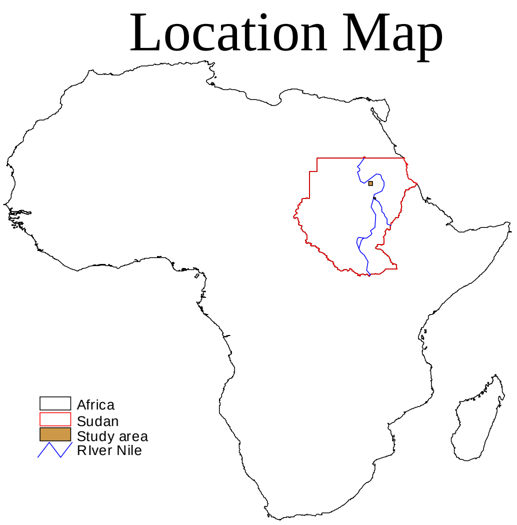


Fig (2) River Nile and Tributaries

is known for its marked seasonal and annual variations. The variation in discharge is illustrated by the fact that more than 80% of its annual flow occurs from August to October and only 20% occurs during the remaining nine months.

Due to the fact that the Nile in the flood season may cause a great damage at the surrounding areas, causing many economical problems for the inhabitants of the flood plains. This study for the high discharge across the Nile and its effects to the surrounding areas according to the topography.

Flood Forecasting

Flood forecasting is an expanding area of application of hydrologic techniques. The goal is to obtain real-time precipitation and stream flow data through a microwave, radio, on satellite communications network, insert the data into rainfall-runoff and streams flow routing programs, and forecast flood flow rates and water levels for periods of from a few hours to a few days ahead, depending on the size of the watershed. Flood forecasts are used to provide warning for people to evacuate areas threatened by floods, and to help water management personnel operate control structures, such as gated spill ways on reservoirs.

Basic Data Requirements

Any forecasting service is dependent on adequate data. The development of the river-forecasting procedures requires historical hydrologic data, while the preparation of operational forecasts requires sufficient current information.

(a) Data for Procedure Development

It is necessary to have a minimum of 10 years of basic hydrologic data available in order to develop adequate river-forecasting procedures. The main requirement, however, is that the period of record should contain a representative range of peak flows. Short records with a limited range of peak flows make it necessary to extrapolate the relations, with a probable loss of accuracy.

(b) Reporting Network for River Forecasting:

The number of reporting (gauging) stations depends upon hydrologic need and availability of observes and communications. The frequency of reports is a function of basin characteristics.

Hydrologic System Model

The objective of hydrologic system analysis is to study the system operation and predict its output. A hydrologic system model is an approximation of the actual system, its inputs and outputs are measurable hydrologic variables and its structure is a set of equations linking the inputs and outputs. Central to the model structure is the concept of a system transformation.

Let the input and output be expressed as function of time, I(t) and Q(t) respectively, for t belonging to the time range T under consideration. The system performs a transformation of the input into the output represented by

$$Q(t) = \underline{\ \cap\ }\ I(t)$$

which is called the transformation equation of the system. The symbol $\underline{\ \cap\ }$ is a transfer function between the input and the output.

By analogy, a hydrologic system is defined as a structure or volume in space, surrounded by a boundary, that accepts water and other inputs, operates on them internally, and produces them as outputs, as shown in Fig.(3).

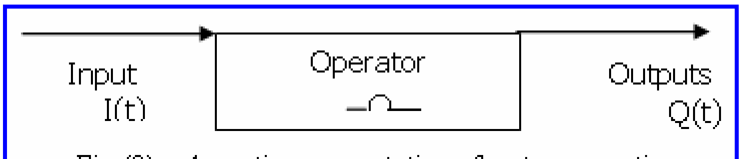


Fig.(3): schematic representation of system operation

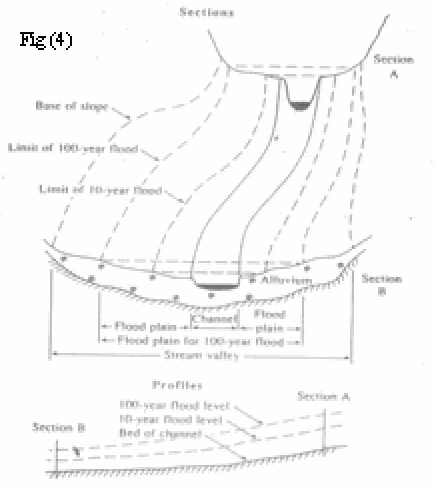
Flood Plain Analysis

A flood plain is the normally dry land area adjoining rivers, streams, lakes, bays, or oceans that is inundated during flood events. The most common causes of flooding are the overflow of streams and rivers and abnormally high tides resulting from severe storms.

The flood plain can include the full width narrow stream valleys, or broad areas along streams in wide, flat valleys.

As shown in Fig.(4) the channel and flood plain are both integral parts of the natural conveyance of a stream. The flood plain carries flow in excess of the channel capacity and the greater the discharge, the further the extent of flow over the flood plain.

Fig(4)



Typical sections and profiles in an unobstructed reach of stream valley.

The first step in any flood plain analysis is to collect data, including topographic maps, flood flow data if a gauging station is nearby, rainfall data if flood flow data are not available, and surveyed cross sections and channel roughness estimates at a number of points along the stream.

A determination of the flood discharge for the desired return period is required, then the next step is to determine the profile of water surface elevation along the channel.

Study Area and Methodology

In this research the study is carried for the Main Nile at Marawe. The study will be taken in two phases.

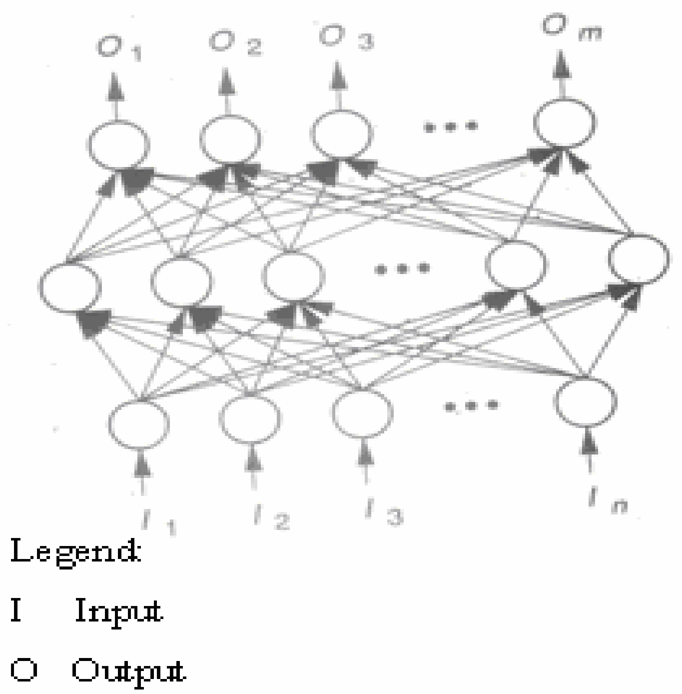
Phase I: is to forecast he flow of the Nile from Khartoum to Dongola. This study will be conducted by the neural artificial network techniques.

Phase II: is to use the Remote Sensing data for the areas at Dongola to get the topography of area. Then by using the GIS we can delineate the flooded areas.

Neural-Network Fundamentals

A neural network is a collection of simple, analog signal processors, connected through links called interconnects, or simply connections. Schematically, neural network is represented in the form of a directed graph, where the nodes represented the processing elements, the arcs represent the modulating connections, and arrowheads on the arcs indicate the normal direction of signal flow.

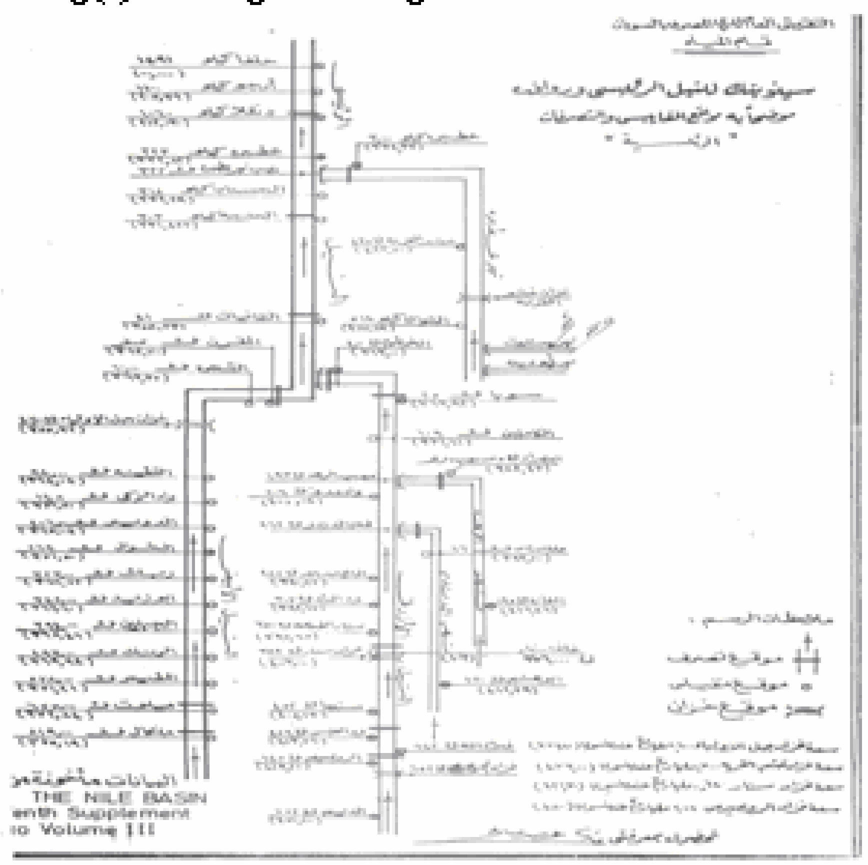
Fig (5) The General Structure of a Layered, Feed-Forward Neural Network



As shown in Fig. (5) the processing elements are usually grouped together into a layered structure known as a slabs, or layer, where each processing element on each layer performs an analog integration of its inputs to determine its activation value.

Processing begins with the entire network in a quiescent state. An external pattern, comprised of a set of signals to be processed by the network, is then applied to the input layer, where each signal stimulates one of the processing elements on the input layer. Each processing element on the input layer generates a single output signal, with a magnitude that is a function of the total stimulation received by the unit collectively, the outputs produced by all of the processing elements on the layer are then passed on as the input pattern to the subsequent layer of processing elements. This process is repeated, until the final layer of processing elements has produced an output for the current input, pattern vector.

Fig (6) Discharge and Gauge Station



Forecasting

Along the Nile these are numbers of stations for Discharge a gauge reading to give daily or monthly records. Fig.(6) show these station. These stations are located at fixed datum, therefore, in our study will choose Khartoum station to forecast the data for Dongola adding to it the flow from Atbara river. These data obtained from Sudan Ministry of Irrigation.

The study will be carried for 30 years from 1965 – 1995. In these years we will take flood season from June till October.

After forecasting using artificial network technique, the Data at Dongola area will be ready for the second step (i.e. phase II). In this phase the remote sensing data will be used to obtain the height of surrounding areas to Dongola. Fig.(7) shows the ortho photo image which will be used to get the contour of area as shown in Fig.(8) , Fig.(9) shows the Digital Terrain Model (DTM). Using GIS model according to the height of water the area that will be covered by the increase of flood level can be mapped.

Fig (7) **Ortho Photo**

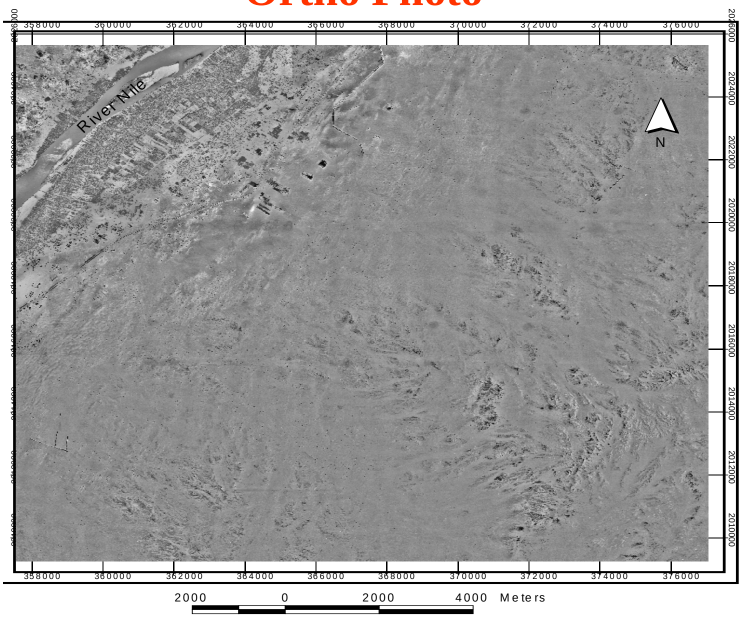


Fig (8) **Contour Map**

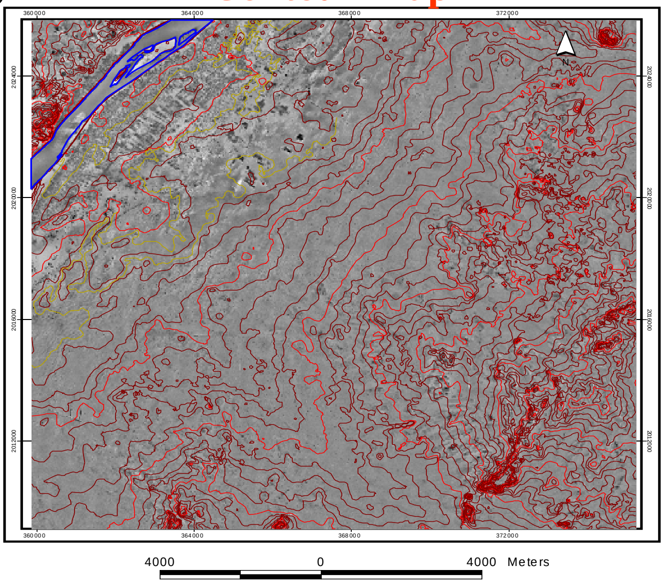
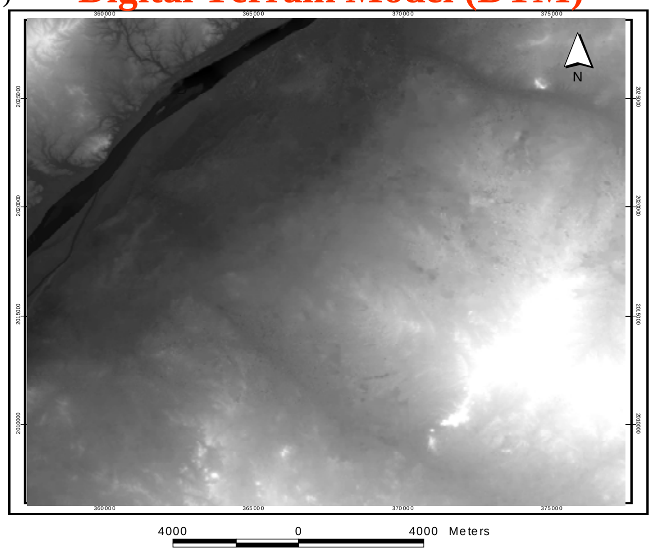


Fig (9) **Digital Terrain Model (DTM)**



Conclusion

In the recent years, Sudan faced flood disasters in the years 1988, 1996, 1998 and 1999.

Although flood is a normal phenomena but when it causes losses in life and damage of property many consideration must b learned to avoid this problem.

This research is taken at Dongola since Dongola faced a big disasters in 1988 flood. Also in high floods which included with high rainfall River Atbara with high discharge coming from Blue Nile causing a high wave which Nile can not carry therefore many areas at North Atbara facing a big problem also the people living in that country adjacent to river.

Therefore, a great effort must be carried to help these people, making a good forecasting model to show areas that can be covered by flood and renewable these models by surveying these areas to get a new topographical maps which give accurate results.

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