Aquatic Science and Fish Resources

http://asfr.journals.ekb.eg

Print ISSN: 2682-4086 Online ISSN: 2682-4108

Topographic Study the rise and fall of the level of the Nile River using Remote Sensing technology and Geographic Information Systems to achieve a comprehensive development management

Heba Abdelmoteleb Ahmed

Civil and Environmental Engineering, Consultant in Water Management Systems

ARTICLE INFO

Article history:
Received Nov. 1, 2022
Received in revised form Nov. 20, 2022
Accepted Nov. 22, 2022
Available online Nov. 28, 2022

Keywords

Nile River, Remote Sensing, Geographic Information Systems, development management, Topography.

Abstract

This paper discusses the use of Remote Sensing technology and Geographic Information Systems that help in real-time monitoring, early warning, and quick damage assessment of Nile flood disasters. Change detection techniques played a significant role in detecting and interpreting the changes that took place in the affected places, having the ability to determine the disaster volume. Showing where concentrating of the water areas, with the distribution of their line, is considered an essential demand in reaching the most affected areas even if it has less water concentration. (DEM) is considered to be the most effective means to estimate flood depth from remotely sensed data. Reaching a flood stream feature is the goal gained to achieve a good understating of the flood manner, which is fulfilled by processing a hydrological map with its slope and aspect, also determining the flood direction and accumulation to have a stream order map reaching the desired flood stream map.

The obtained results considered crucial information for decision-makers for future effective flash floods hazard mitigation, assessment management, planning, and sustainable development.

INTRODUCTION

The eastern Nile region (which includes Egypt, Ethiopia, and Sudan) is characterized by highly variable river flows, making it prone to floods and droughts, with devastating effects on lives. Floods have real consequences for poverty and food security. Hydrological They reduce agricultural production, decrease incomes, increase risks of sickness and disease, disrupt education, and damage public infrastructure and private assets.

* Corresponding: motelebheba@gmail.com

doi: 10.21608/ASFR.2022.175513.1026

Without the good knowledge of the complex topography and sub-basin characteristics, one cannot see the process of the basin **(Sutcliffe and Parks, 1999)**. The Nile as a large river basin holds diverse topographic features as mountainous, lakes, depressions, vast wetlands, floodplains and gorges. Most of the basin area lies in the low land ranges, which has an altitude of less than 1500 m above mean sea level (amsl). But due to limitation in technical ability to collect good topographic information, they could not address some of the details of topographic variations of the Nile basin. This work goes into further details using different the Remote Sensing techniques that have been performed in order to enhance the Landsat image for a better geological interpretation, where one of its most powerful tools is the Digital Elevation Model (DEM) integrated with the spatial analysis tools of ArcGIS. Rainfall is an important parameter for water balance analysis and inflows into the system are dependent on this parameter. The spatial and temporal distribution of rainfall can have different impact on distinct runoff generation processes **(Tetzlaff and Uhlenbrook, 2005)**. The rainfall in the Nile River basin ranges from high rainfall in the most upstream reaches of the equatorial lake's region and the Ethiopian highlands; about 2000 mm mean annual rainfall, to arid desert condition downstream regions that receives no rainfall in a year **(Batisha, 2012)**. This climatic variability is possibly observed due to the large extent coverage of latitude (36°) and longitude (18°), large altitudinal variation (8 m below sea level to 4567 m above sea level) and the different monsoons (the longer southeasterly and shorter northeasterly monsoons) over the basin **(Sutcliffe and Parks, 1999)**. The mean monthly and annual rainfall data over the Nile basin were extracted from very high resolution interpolated global dataset CHRS Data portal.

STUDY AREA

The Nile River is the longest river in the world. It is about 6,853 kilometers in length, but its exact length is still not specified. The river flows in eastern Africa through the equatorial climate to the north, and into the Mediterranean, and passes through eleven countries, namely: Tanzania, Rwanda, Burundi, Uganda, the Democratic Republic of the Congo, Eritrea, Kenya, Ethiopia, South Sudan, Sudan, and Egypt. The source of the White Nile in the Great Lakes region in Central Africa, the farthest source is found in southern Rwanda and runs from northern Tanzania to Lake Victoria, to Uganda and then to southern Sudan, while the Blue Nile begins in Lake Tana in Ethiopia and then flows to Sudan from the southeast and then the rivers meet at the Sudanese capital, Khartoum. The discharge of the White Nile is approximately constant over the whole year, while the Blue Nile gives more than 80% of its share between July and August during the rainy season in the highlands of Ethiopia **(Abd-El Monsef *et al.,* 2015)**. The Blue Nile comes with a percentage (80-85%) of the water feeding the Nile, but this water reaches it in summer only during the monsoon rains on the Abyssinia plateau, which is known as the Nile flood, while it does not constitute in the rest of the days of the year the same percentage as the water decreases.

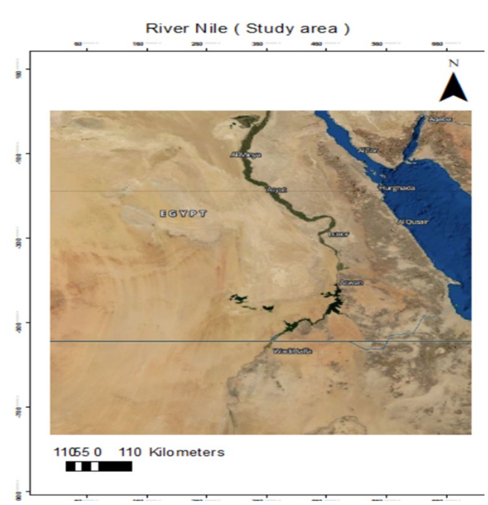


Fig.1. A map of the River Nile

The aim of this work is to study of the conditions of the Nile River in terms of an increase in the level due to the possibility of its exposure to floods or a decrease in the level as a result of drought for Adaptation to Climate Change and Disaster Risk Reduction reaching a complete management to achieve sustainable development.

DATA AND SOFTWARE USED

Landsat images

They are satellite images that had been used to extract different types of info-layers, were acquired from the Earth Explorer's website: https://earthexplorer.usgs.gov/, where datum and ellipsoid are WGS84. [Landsat 8 OLI (Operational Land Imager) and TIRS (Thermal Infrared Sensor) 15- to 30- meter multispectral data from Landsat 8].

CHRS Data Portal

It is an archive for global produced by thew PERSIANN, PERSIANN-CSS and PERSIANN-CDR developed by the center for hydrometeorology & Remote sensing (**CHRS**, http://chrs.web.uci.edu).

Arc GIS 10.8 program was used for the different data processing. ArcMap, ArcCatalog, the ArcGIS Desktop applications to create maps, perform spatial analysis, manage geographic data. Released Version: 10.8.1 (July 2020) Previous Version: 10.8 (February 2020).

MATERIALS AND METHODS

The methodology including data analysis, screening, and interpretation of available data and maps; such as satellite images (GIS and Remote sensing techniques using different maps and images).

Study methodology was built on the following steps:

1. Integrated imagery coverage
2. Satellite data acquisition and pre-processing
3. Image processing and interpretation
4. Photo-interpretation activity
5. Data arrangement
6. Validation process

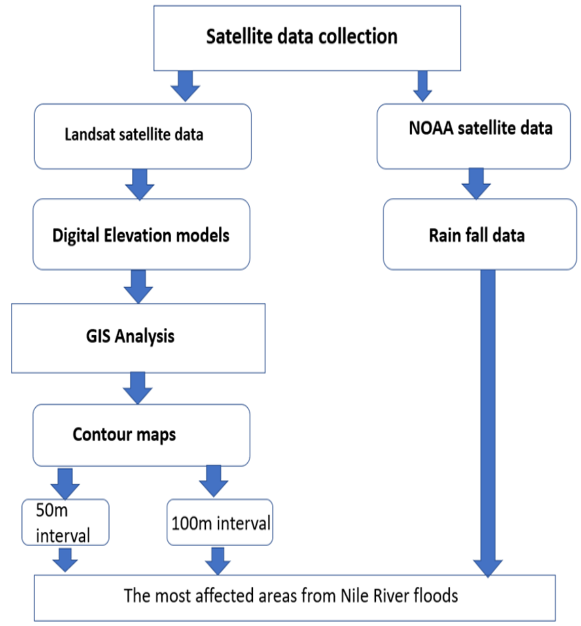


Fig.2. Methodology of the work

RESULTS AND DISCUSSION

Firstly, Study the topography of the study area

Depending only on the visual interpretation of the satellite image (the Landsat 8 & the Digital Elevations), and using the GIS computer programs as Arc map, in performing Contour and Tin maps.

The Study area was divided into eight sections, studying every section individually. Every section has its Contour map and its digital elevation map illustrating its topographic features, with two contour intervals (50m & 100m).

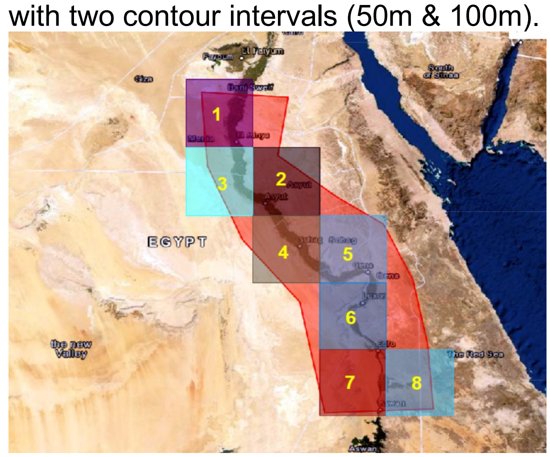


Fig.3. Map of the divided sections of the study area

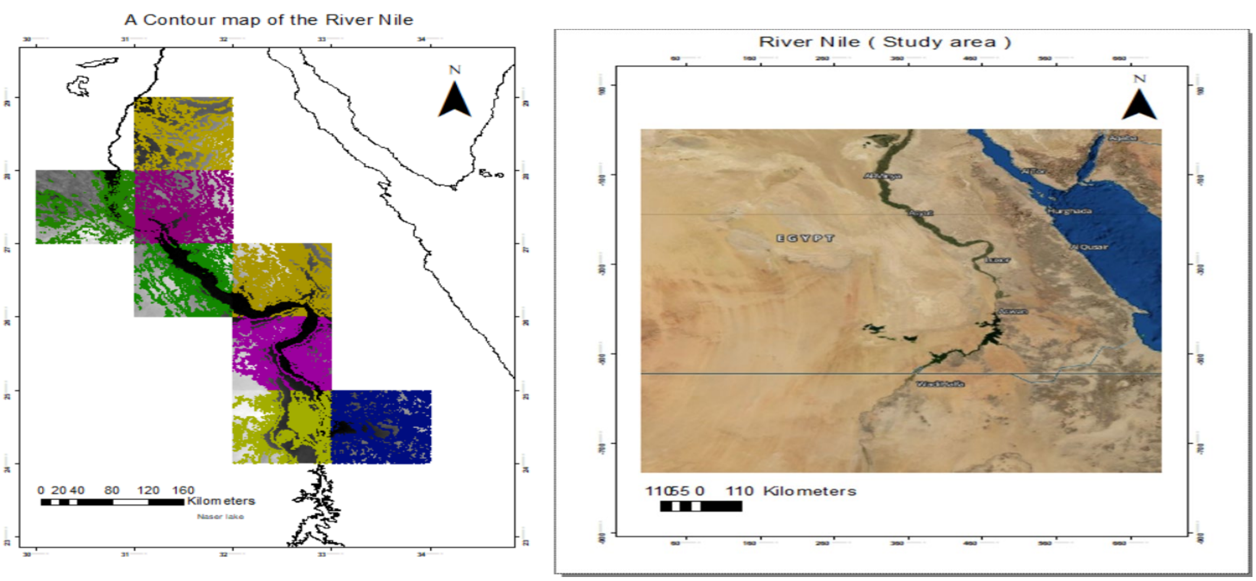


Fig.4. Map of the elevations divided sections of the study area

The present study uses the raw satellite data with the different Elevation map for each raw satellite section image of the Nile River. The variation of flow is caused mainly by the morphometric parameters derived from the elevation and topographic maps of the drainage basins along all the sections of the Nile River.

Elevations of the River Nile sections, Landsat 8 satellite data

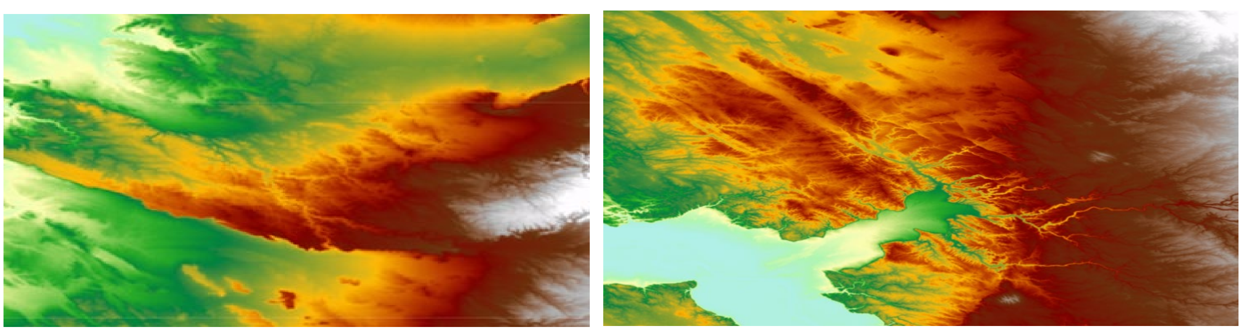


Fig.5.Elevations Sections 1 and 2 respectively

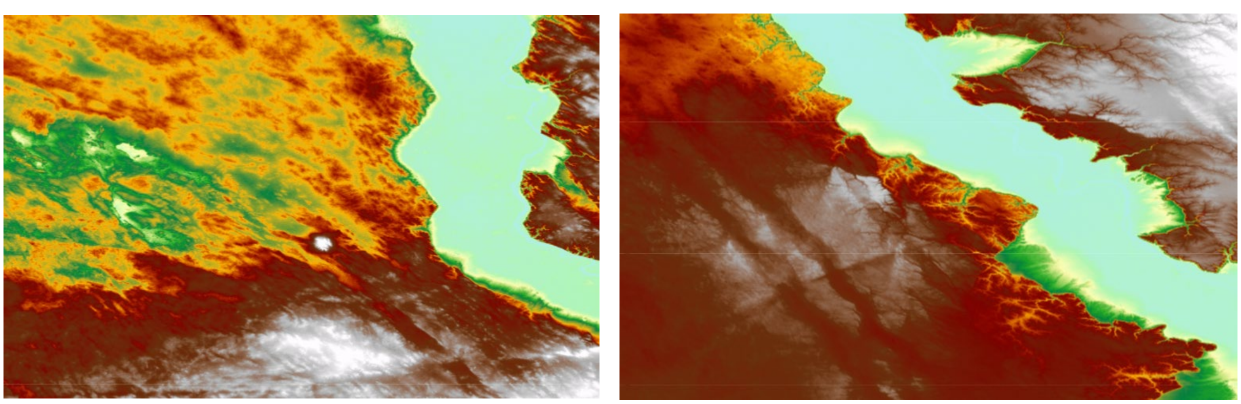


Fig.6. Elevations Sections 3 and 4 respectively

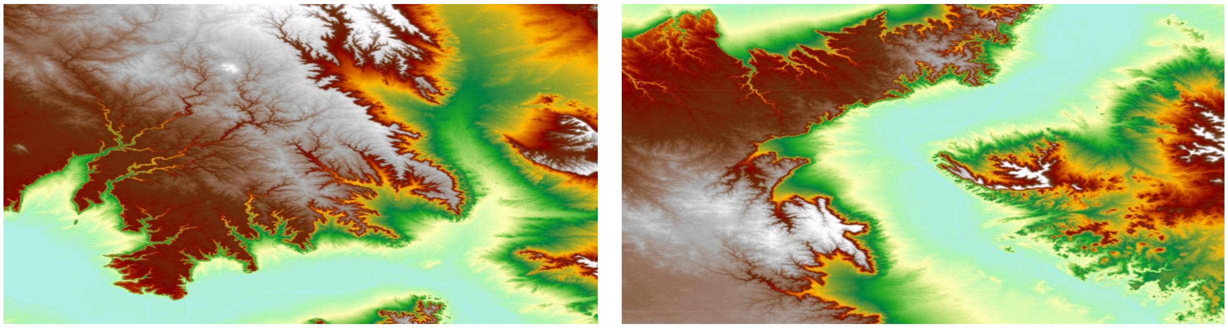


Fig.7. Elevations Sections 5 and 6 respectively

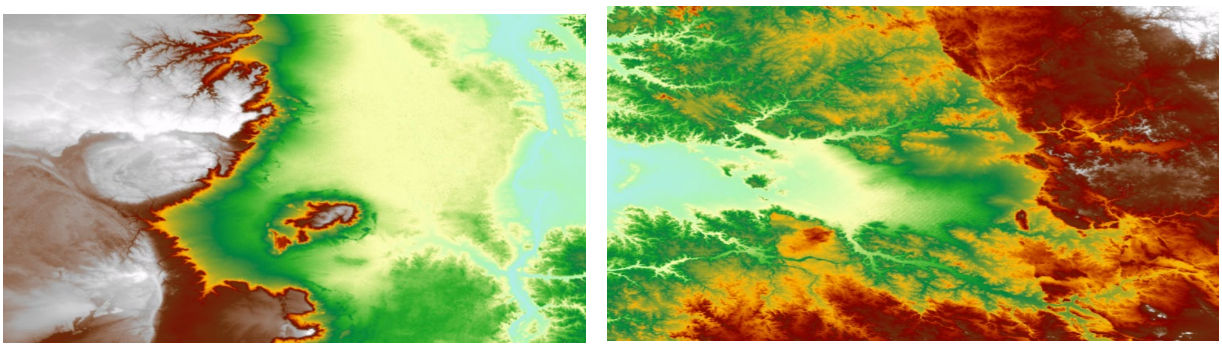


Fig.8. Elevations Sections 7 and 8 respectively

Every Satellite Imaging of each section of the eights sections of the Nile River provides orthorectified mono and stereo satellite imagery that can be processed for visual of terrain conditions in 2D and 3D production of digital elevation models (DEM) from various Landsat satellite sensors with different bands including the Nile 3D vision, This data can aid and support project planners, emergency operation managers, and logistics managers to plan field operations of the different topographic features of the study area in a computer environment ensuring that the best terrain conditions and access is provided to achieve project objectives.

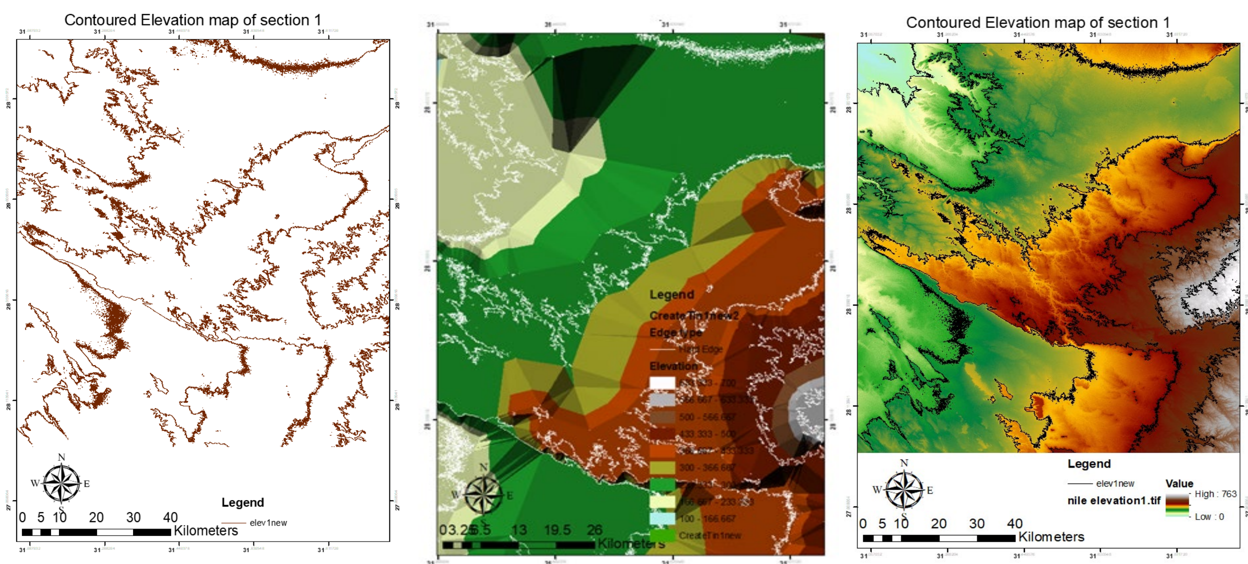


Fig.9.Contour map of section1 with interval of 100m, Tin map of section, and A Contoured Digital

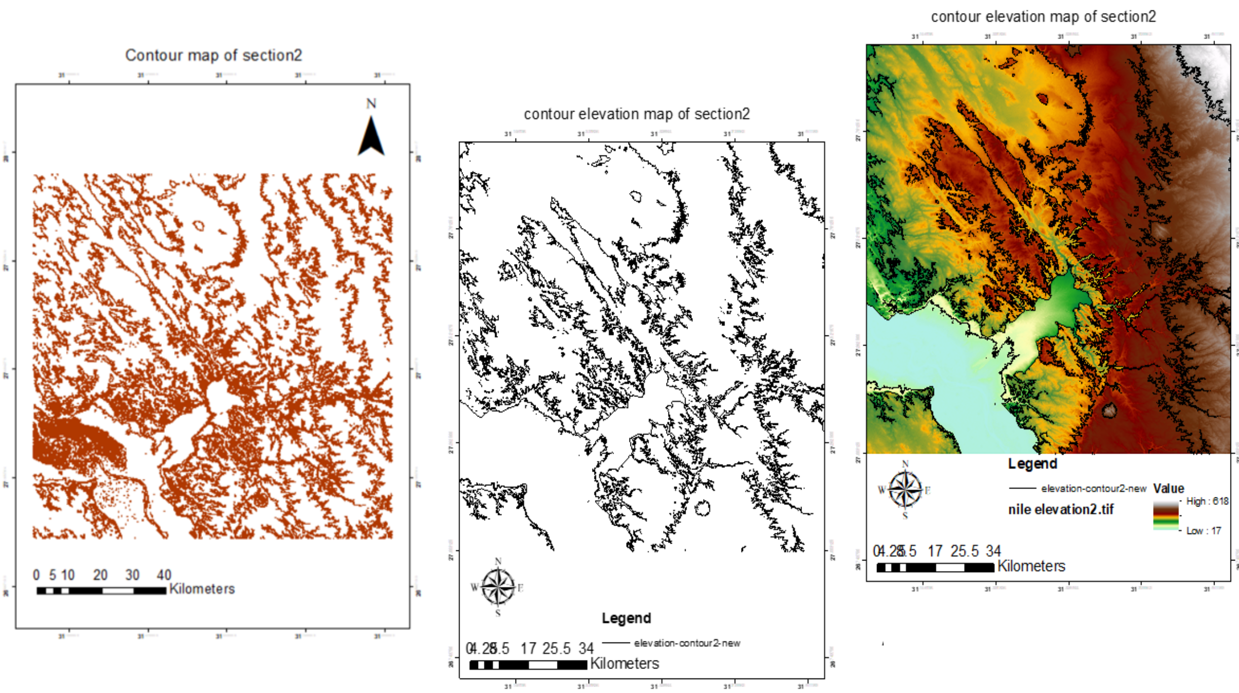


Fig.10.Contour map of section2 with interval of 100m, Tin map of section, and A Contoured Digital Elevation map respectively

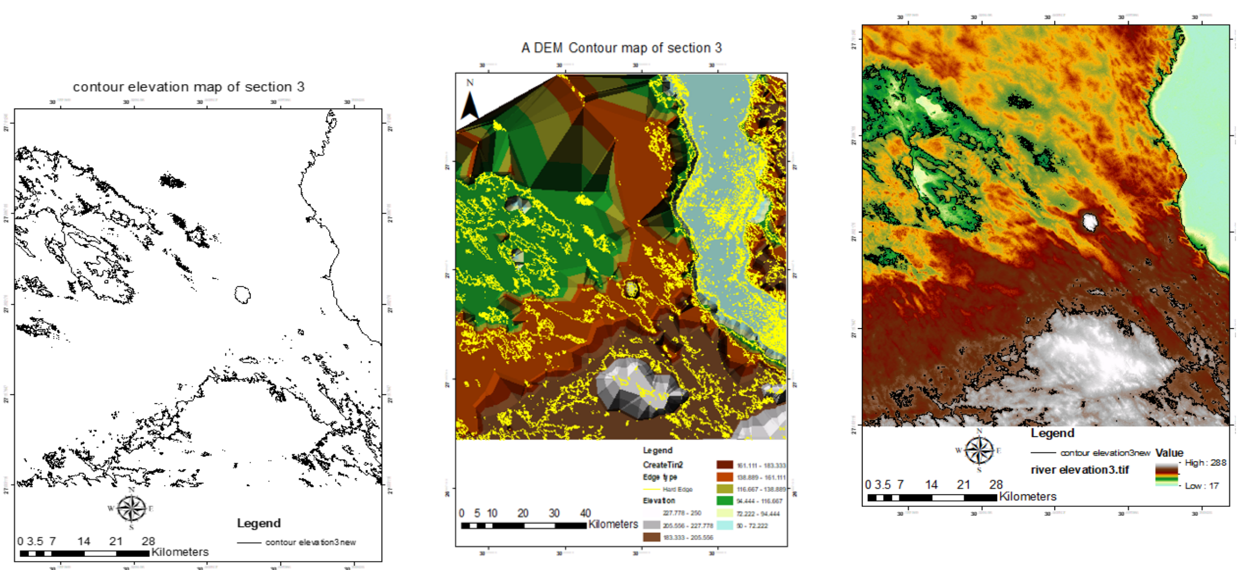


Fig.11. Contour map of section 3 with interval of 100m, Tin map of section, and A Contoured Digital Elevation map respectively

The Nile River from Al Fayium in Egypt to Al Khartoum in Sudan is divided into three stages.
The first stage: from Al Fayium to the beginning of Lake Naser in Egypt.
The second stage: Lake Naser in Egypt.
The third stage: from the end of Lake Naser to Al Khartoum in Sudan.

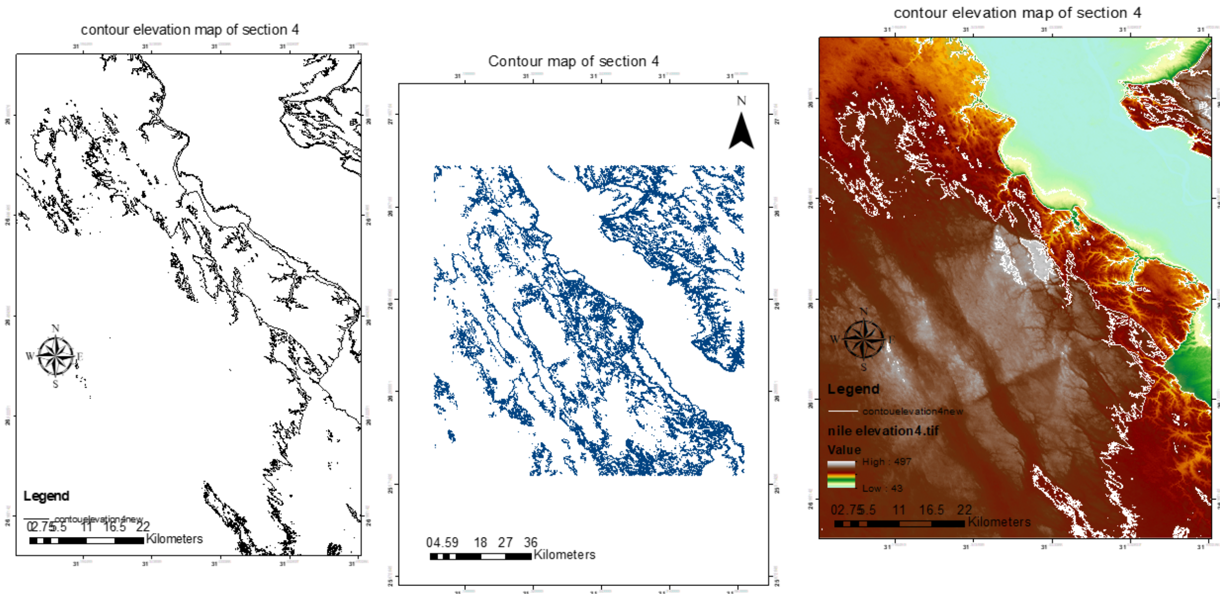


Fig.12.Contour map of section 4 with interval of 100m, Tin map of section, and A Contoured Digital Elevation map respectively

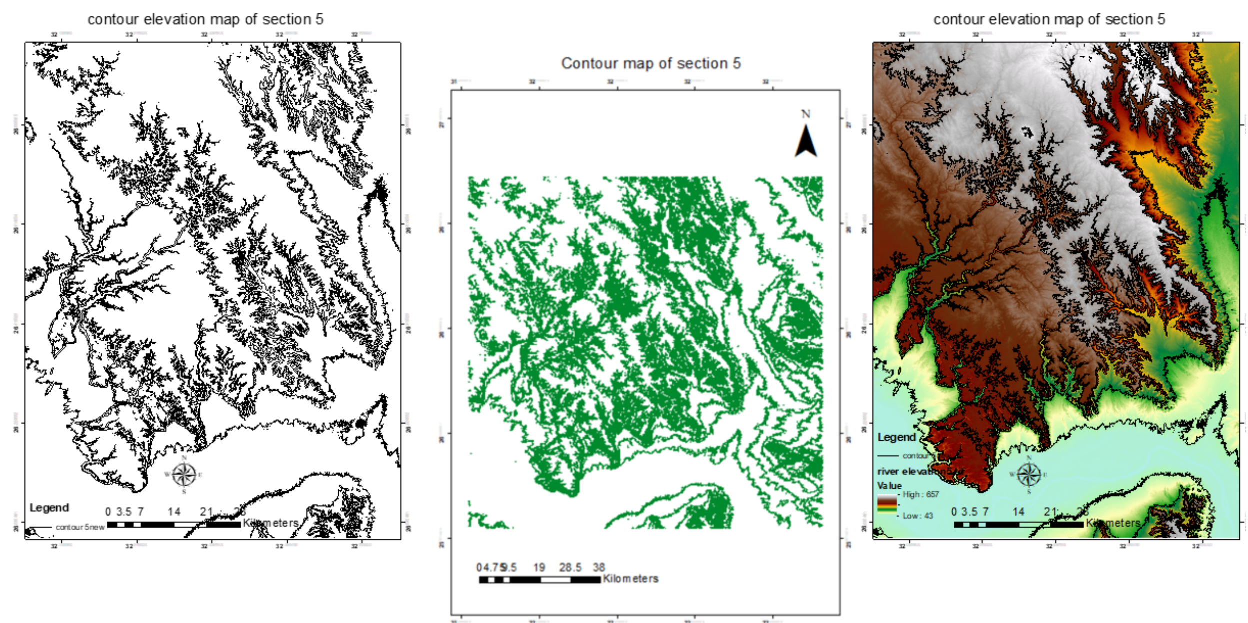


Fig.13. Contour map of section 5 with interval of 100m, Tin map of section, and A Contoured Digital Elevation map respectively

Contour are lines drawn in each section map to show the areas with equal altitude, showing the landforms of each area by contours with the contour lines on the map to provide a useful insight into the topography of each area and their shapes represent the height and slope or gradient of the landforms. closely spaced contour lines represent steep slopes while widely spaced contours represent gentle slope. when two or more contour lines merge with each other, they represent feature of vertical slope such as cliff and waterfall, two contours of different elevation usually do not cross each other showing how the behavior and the path of the water in case of predicted floods or flash floods.

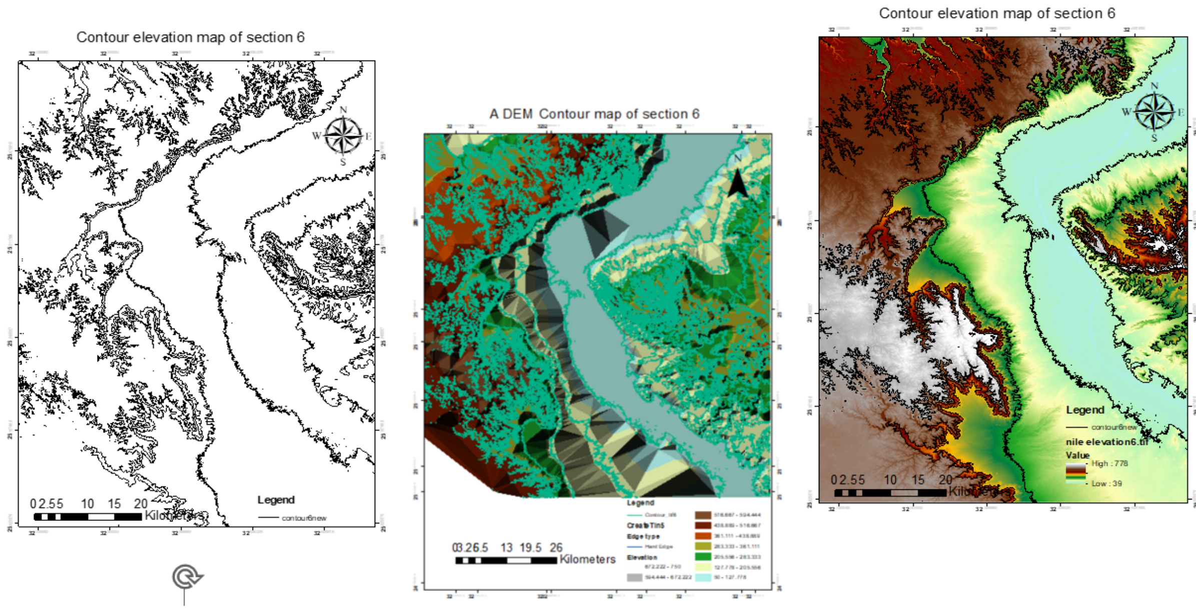


Fig.14. Contour map of section 6 with interval of 100m, Tin map of section, and A Contoured Digital Elevation map respectively

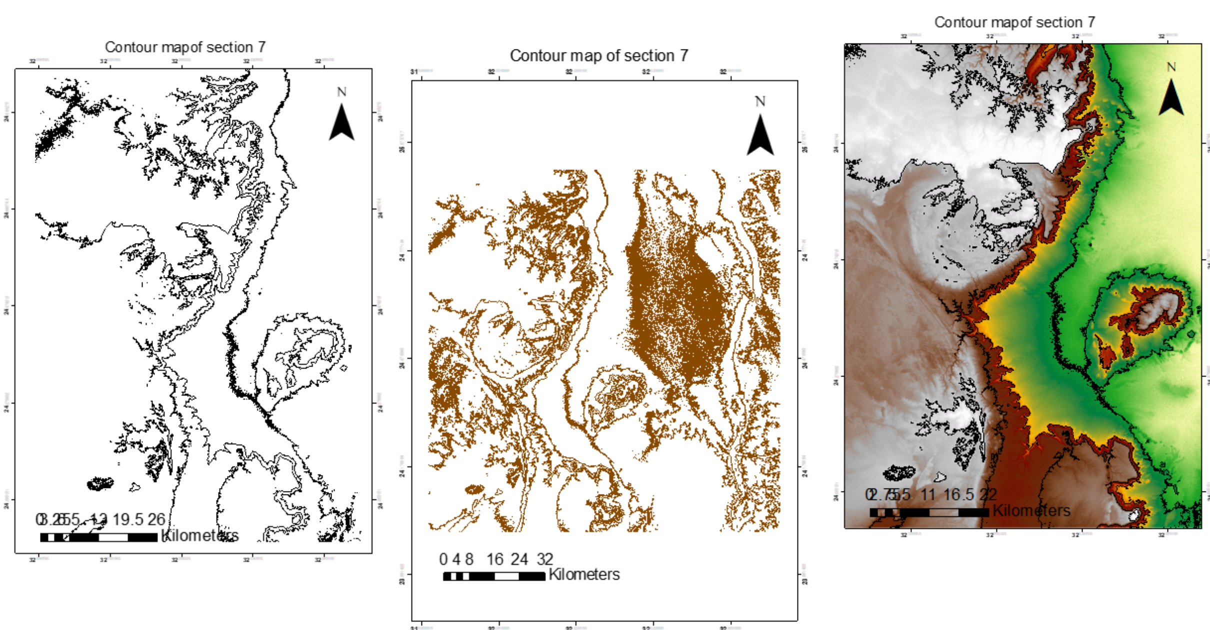


Fig.15. Contour map of section 7 with interval of 100m, Tin map of section, and A Contoured Digital
Elevation map respectively

Using the Erdas Imagine and the Arc Map software of Remote Sensing and the Geographic Information Systems for changing each satellite image to Elevation image EDM, shapefile processing and applying the contouring methods with different contour intervals, then overlaying the resulted topographic map with the satellite image illustrating the different topographic paths assessment of the floods in the different Nile sections.

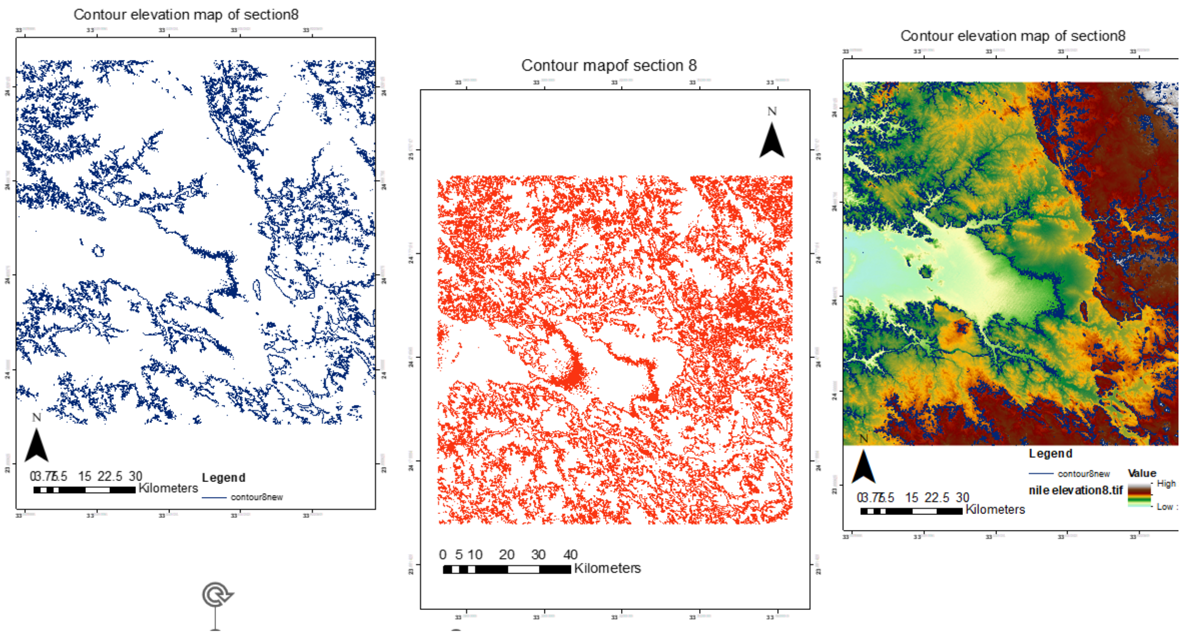


Fig.16. Contour map of section 7 with interval of 100m, Tin map of section, and A Contoured Digital Elevation map respectively

The deepest area is that area located at Minya between Bany Suef and Assiut, and the highest section of them is that the area lies at the beginning of Lake Naser and at Al Fayoum.

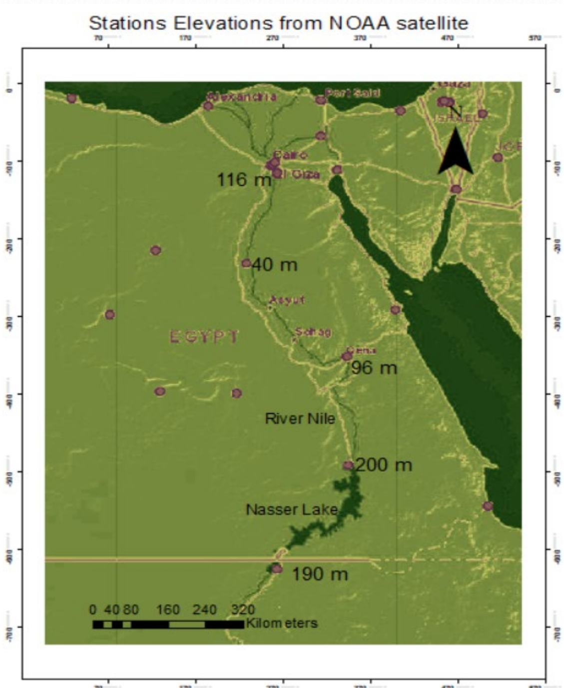
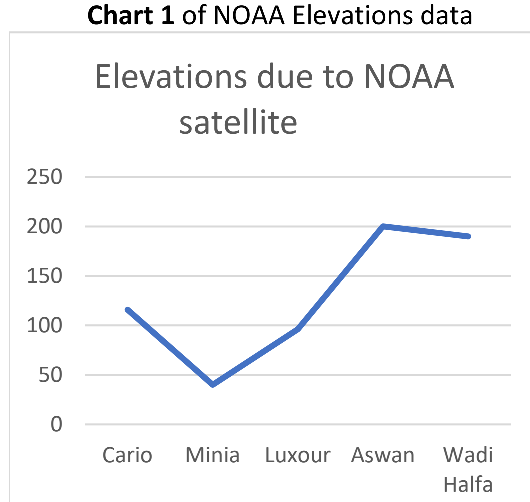


Fig.17. Elevations from NOAA data

The integrated results of the satellite remote sensing and GIS data performing all the different analyses of the data producing both of the elevation and contour map that are used for assessing and mapping the flood hazard the topographic nature of the Nile River as discussed in the previous sections, and according to the data extracted from the Indian NOAA satellite, representing in the following chat.

Chart 1 of NOAA Elevations data



After the Nile River region was divided from the bottom of Fayoum to Lake Nasser (the study area) into eight sections, and each section had its Digital Elevation map studied to make contour maps with a distance of 50 m and 100 m to know the topography of each section. So after obtaining the results and their analysis, it was found that the deepest area is that area located at Minya between Bany Suef and Assiut, and the highest section of them is that the area lies at the beginning of Lake Naser and at Al Fayoum. It was realized from this, that in the event of rain falling from the south of Sudan or the Ethiopian plateau, or even rain falling on Egypt, even if it does not rise to floods, the rains will flow towards this region and the rain will flash falls on the northern part of the Nile River region or the eastern delta rains. This rains will also flow into the same area. In addition, the eastern side of this region are the roads linking Minya, Assiut and Sohag to the coast of the Red Sea, passing through the eastern desert, which is characterized by its topography and is subject to strong floods in the Autum and winter seasons.

CONCULION

It has been shown from the study that the areas with the highest terrain are these areas that have been most exposed to rain and usually reach the level of floods, where this indicates that the flashing rains or floods will come from the southern region of the Nile and from the eastern region in the form of flashing floods, causing devastating floods in the areas between the two districts of Bany Suef and Assiut, and also affecting the roads linking the path along the Nile and the Red Sea coast, located in the eastern desert.

RECOMMENDATIONS

1-Enhancing the capacity to absorb and contain climate-related risks and disasters:

This is attainable through the development of specialized sectorial programs and action plans to meet the needs of the community at large, and to adapt to the new conditions through various means, ranging from basic fundamentals to the use of state-of–the-art technologies. In this manner, systems are set up for adaptation to potential climate changes, namely temperature increase and water scarcity, and the adverse expectations on the increase and decrease of precipitation and sea level rise.

2-Continuation of the implementation of the removal of encroachments on waterways, especially in areas that are recommended to be more vulnerable to flooding.

3-Work to raise the efficiency of all pumping stations, canals, drains, and torrents to ensure their readiness to contain flood water.

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