United Nations/Islamic Republic of Iran Regional Workshop

on the Use of Space Technology for Environmental Security, Disaster Rehabilitation and Sustainable Development.

Remote Sensing for Assessment and Evaluation of geomorphological Hazards with Reference to Floods for Eastern Part of Khartoum State – Sudan

Presented by

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Abstract

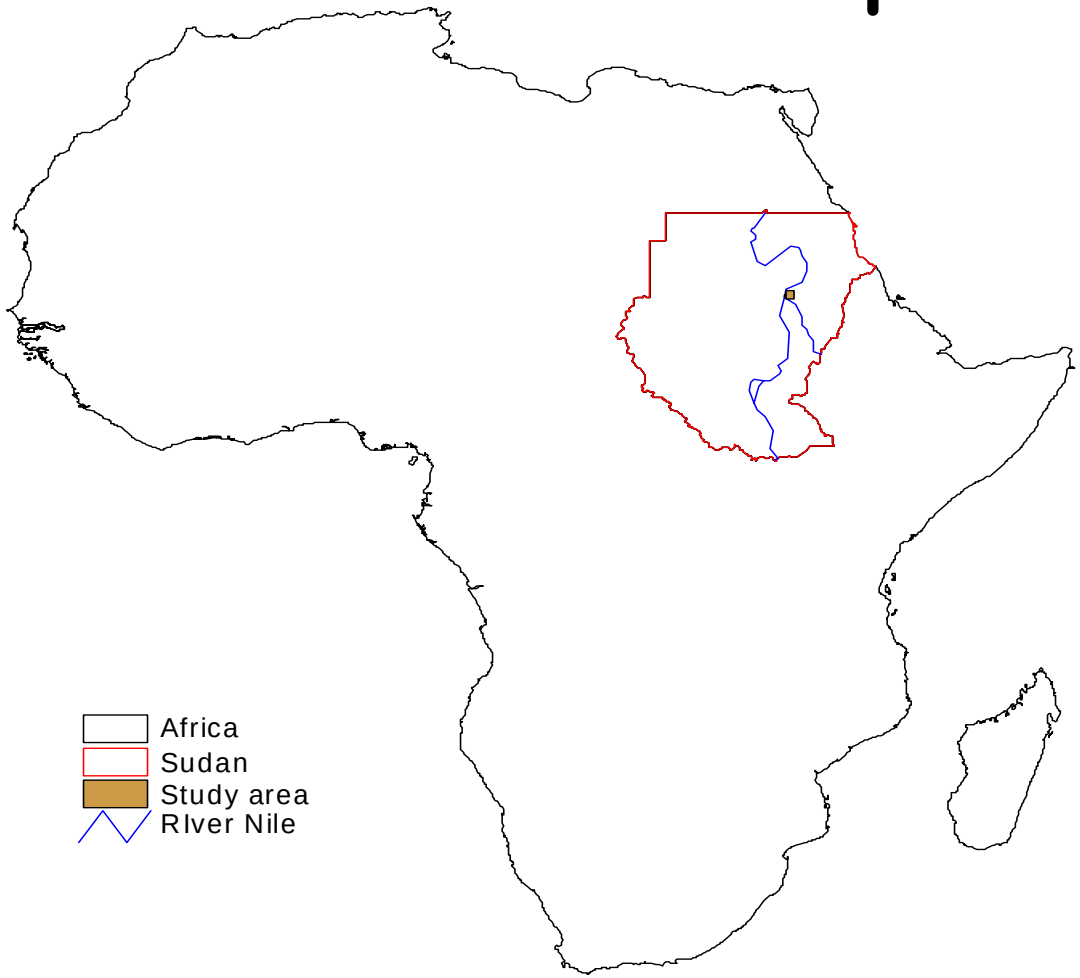
In this study, remote sensing augmented with conventional methods, field survey, topographic maps and ancillary data were utilized to assess and evaluate the geomorphological hazards with reference to flooding. The results of the study are whenever Nile flood is coupled by torrential rainfall. Damage to property, extensive destruction to cultivation and unhealthy environment were prevailing. Good examples 1988, 1998, and 2001 floods. The most vulnerable areas are at the Nile and Wadis flood prone areas. The study revealed that vulnerability levels increase with every influx because new arrivals often build their shelters in the flood prone areas every year Khartoum State Receives about 20000 person and its total population estimated one-third country population. The geomorphology of the area has its own contribution, too. Catchment area is the highest place in the study area and most outcrops of the area are distributed along the catchment, so, Wadis flow towards the Nile at highly destructive speeds. Lack of detailed base and thematic maps and political intervention were some of the factors behind miss landuse in the area. Remote sensing was found to be an effective tool for assessing and evaluating such geomorphological hazards.

Introduction

Sudan is the largest country in Africa with an area of 2.5 million km². Sudan has a diversified climate ranging from a desert in the North to equatorial in the South. Annual rainfall amounts exceed 1500 mm in the south and below 100 mm in the extreme north.

The study area is a part from Khartoum State (where 1/3 of the Sudan's population lives). The area is located between latitude 15.28' – 16.08' and longitude 32.43' – 33.70', about 110,000 km². The climate is semi-arid with annual rainfall ranging from 100 to 300 mm. The last decade showed a trend of rainfall increment. Older and stabilized sand dunes are the dominant, while older Nile deposits and Wadi deposits are the most fertile clay soils. The geological units available in the area are Granitic basement in the north east, Omdurman formation (Lower part) and Older and stabilized sand dunes are the dominating the central part. Umrawaba formation and cretaceous with Quaternary cover dominating the southern part. Contour data of the area shows a trend of graduated slopping from east to west.

Location Map



Study area covers….Sqr km east of Khartoum State-Sudan

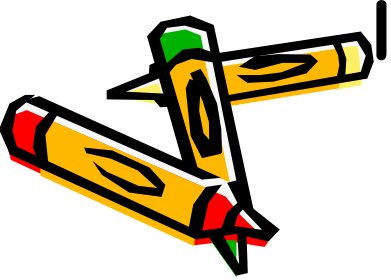
Historically the area was subject to many floods 1942, 1988, 1994, 1998 and 2001. Some of these were normal while others were very destructive such as 1988 flood. In early August 1988, severe floods struck the study area. In one day 210 mm of rainfall were recorded, about 1000 families lost their homes completely and about 2000 lost parts of their homes in Khartoum State. In 1998 another flood struck the area, damage to houses was most severe than that of 1988. Over 6000 houses were completely damaged, while another 6000 were partially destroyed, 90000 people were directly affected. In 2001 floods, the Nile water level was the highest for more than 20 years, including 1988 floods, although damages and environmental conditions were very less severe compared to that of 1988. This was due to the fact that torrential rainfalls were not accompanied with the Nile floods as occurred in 1988. The flash floods occurrence in the study area is due to semi arid conditions, sparse vegetation cover, steep topography, and heavy rainstorms with very short duration. Flood could be defined as the height of water above the banks of the normal river channel. In the study area, the broadness and the shallowness (mainly at the delta or down stream of Wadis) of the water channels (Wadis) serve flooding, while the heavy rainstorm Serves flash flood.

Research Problem

The idea of the study is developed from the fact that the whole area was subject to successive flood. Certain areas received severe destruction while others not.

Objectives

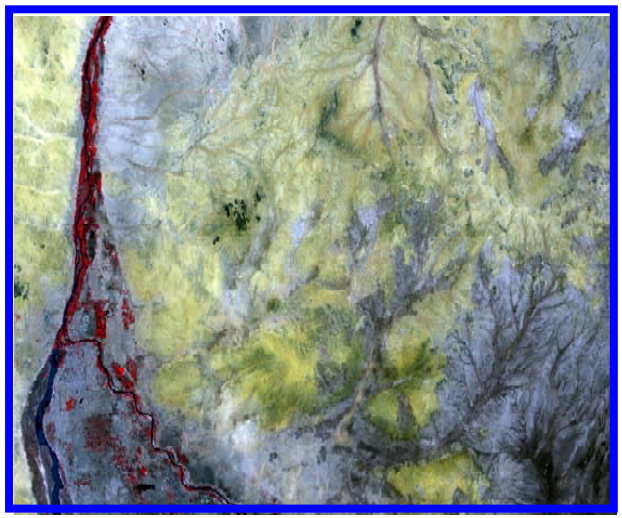
1. To examine the causes of the geomorphologic hazards and environmental consequences, with particular reference to flooding.
2. To evaluate the role of remote sensing technology in assessing and evaluating geomorphological hazards occurred in the study area.
3. To use the GIS for data analysis and problem solving.
4. To use simple methods to produce valuable information, i.e. to determine the environmentally risk areas due to their location in the flood prone areas or inside waterways (Wadis).



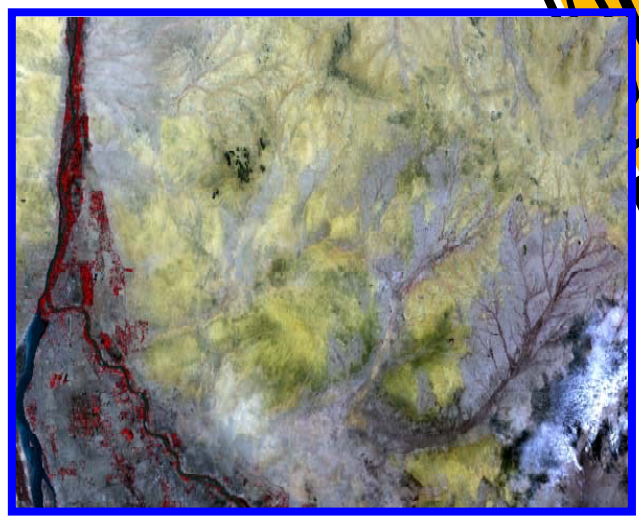
Materials and Methods

Landsat TM data for the years 1989, 1996, 2000, respectively, were used. SPOT image of 2001 was also used. Data have been interpreted, processed and analyzed using digital image processing and GIS software. Other topographical maps of scale 1:250,000 and 1: 100,000, produced by Sudan Survey Department, were also used together with the data collected from field visits and other ancillary data sources. Several thematic maps were extracted.

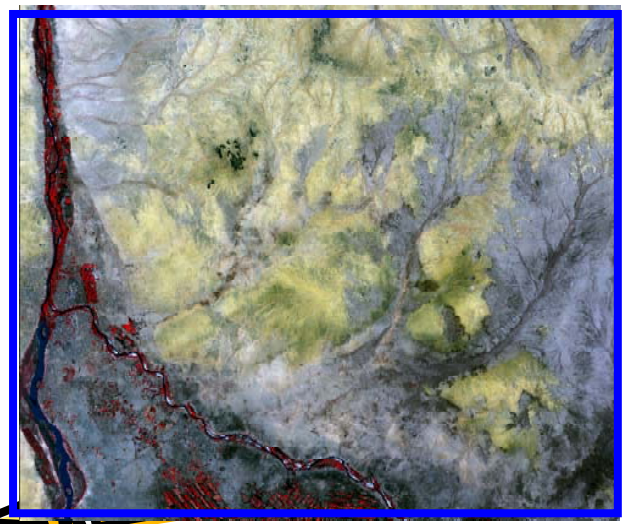
Space data utilized in the study



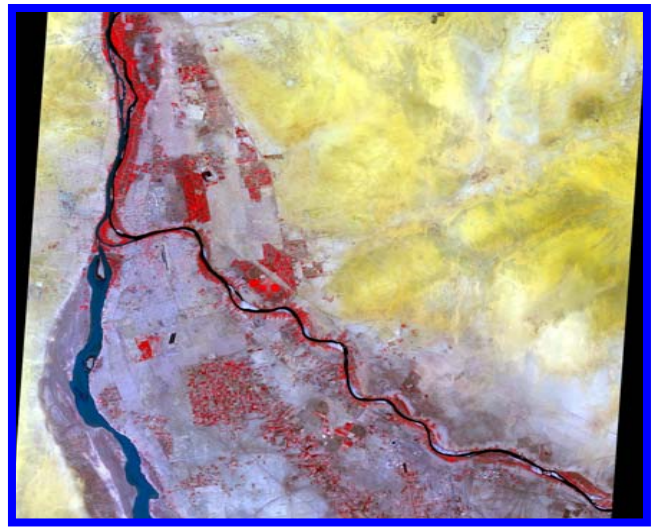
Landsat ETM 2000



Landsat TM 1996



Landsat TM 1989



SPOT 2001

Data have been digitally and visually interpreted

Findings

1-Literature Preview

Climate: Semi-arid with sparse vegetation, which supports the occurrence of flash floods in the area.

Soil: In general, the soil is a sandy soil. Older and stabilized sand dunes are the dominant, while older Nile deposits and Wadi deposits are the most fertile clay soils. These fertile soils mainly found at flood prone areas.

Rainfall: Annual rainfall ranging from 100 to 300 mm. The last decade showed a trend of rainfall increment.

Human movements: Recently, Khartoum state population estimated as one-third of Sudan total population. Khartoum State every year receives about 200,000 persons from the different States. Some of these people build their shelters in the environmentally risk areas – mainly areas under flood risk.

Geomorphology and Geology: The geological units available in the area are Granitic basement in the north east, Omdurman formation (Lower part) and Older and stabilized sand dunes are the dominating the central part. Umrawaba formation and cretaceous with Quaternary cover dominating the southern part. These geological features combined together with moving sands and graduated slopping toward the Nile, combined to form a type of extended broad Wadis. Contour data of the area shows a trend of graduated slopping from east to west where Nile is spread. Many outcrops were scatted along the area that watershed line coming through. This why Wadis flow is destructive when rainfall is heavy.

Maps: Topographical maps scale 1: 100,000 and 1: 250,000 are the only maps produced by the survey department for the area. No detailed thematic maps. Remote sensing data was not incorporated in urban and agricultural planning for the area.

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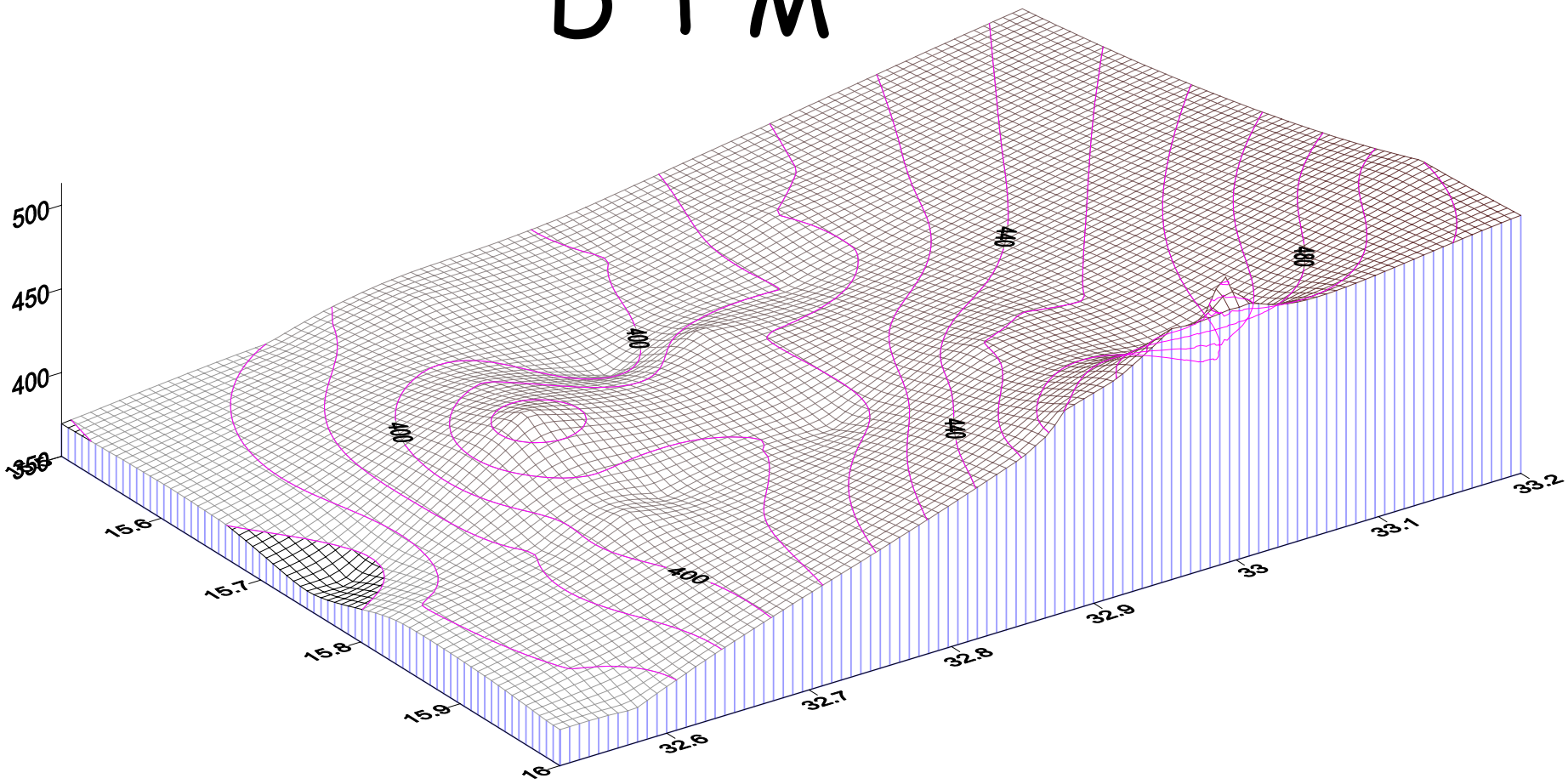
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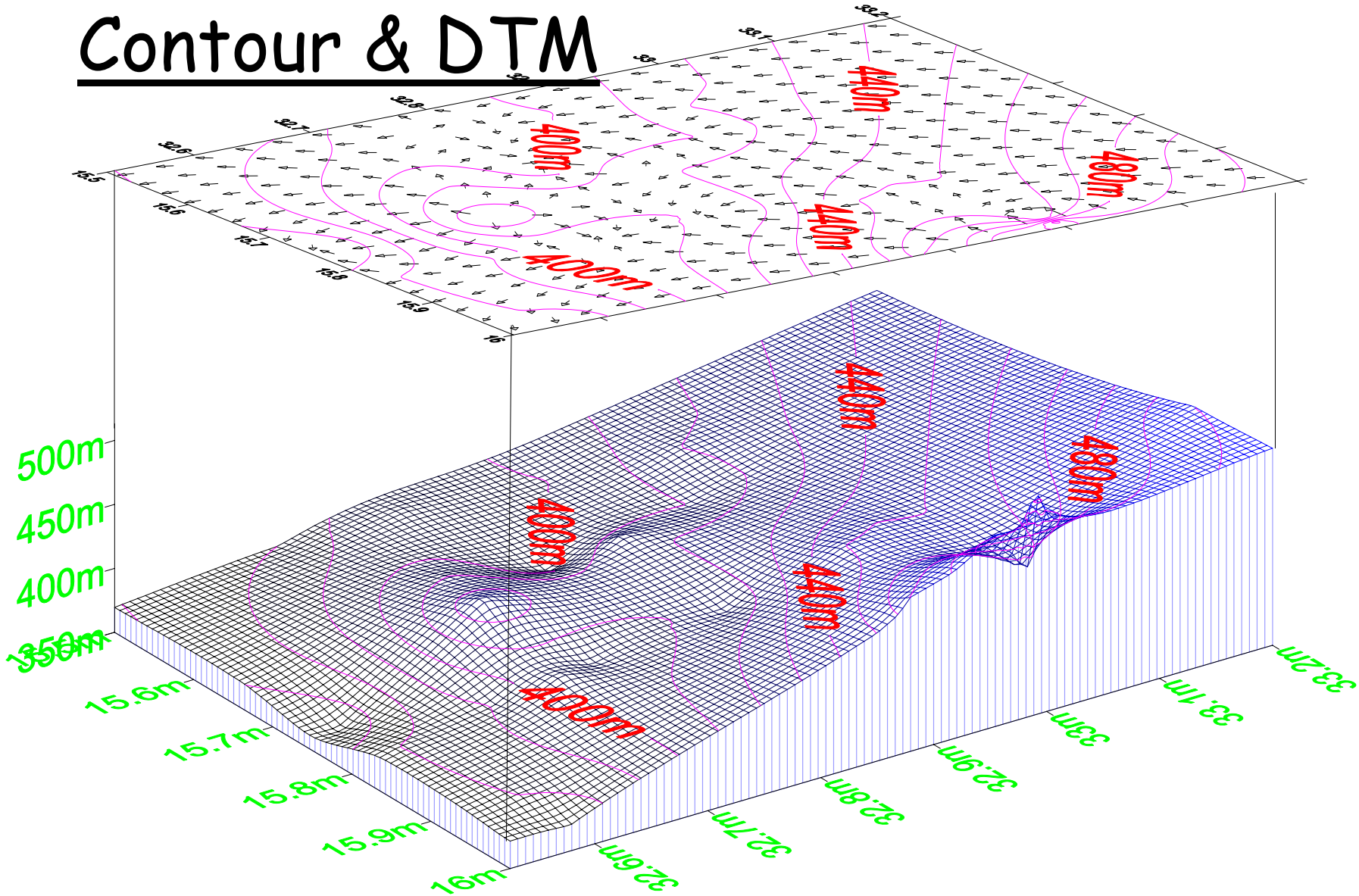
Contour & DTM



Graduated slopping towards Nile and Wadis flow direction

Findings

2. Field Visits

Three filed visits were conducted, during 2000, 2001, and 2002, respectively. Objectives: mainly for ground truthing and for geomorphological and environmental data collection. Forests were developed inside Wadis. Vegetation cover, in general, is sparse. Some Wadis were identified in satellite data but not be observed on ground. This was due to their broadness and shallowness.

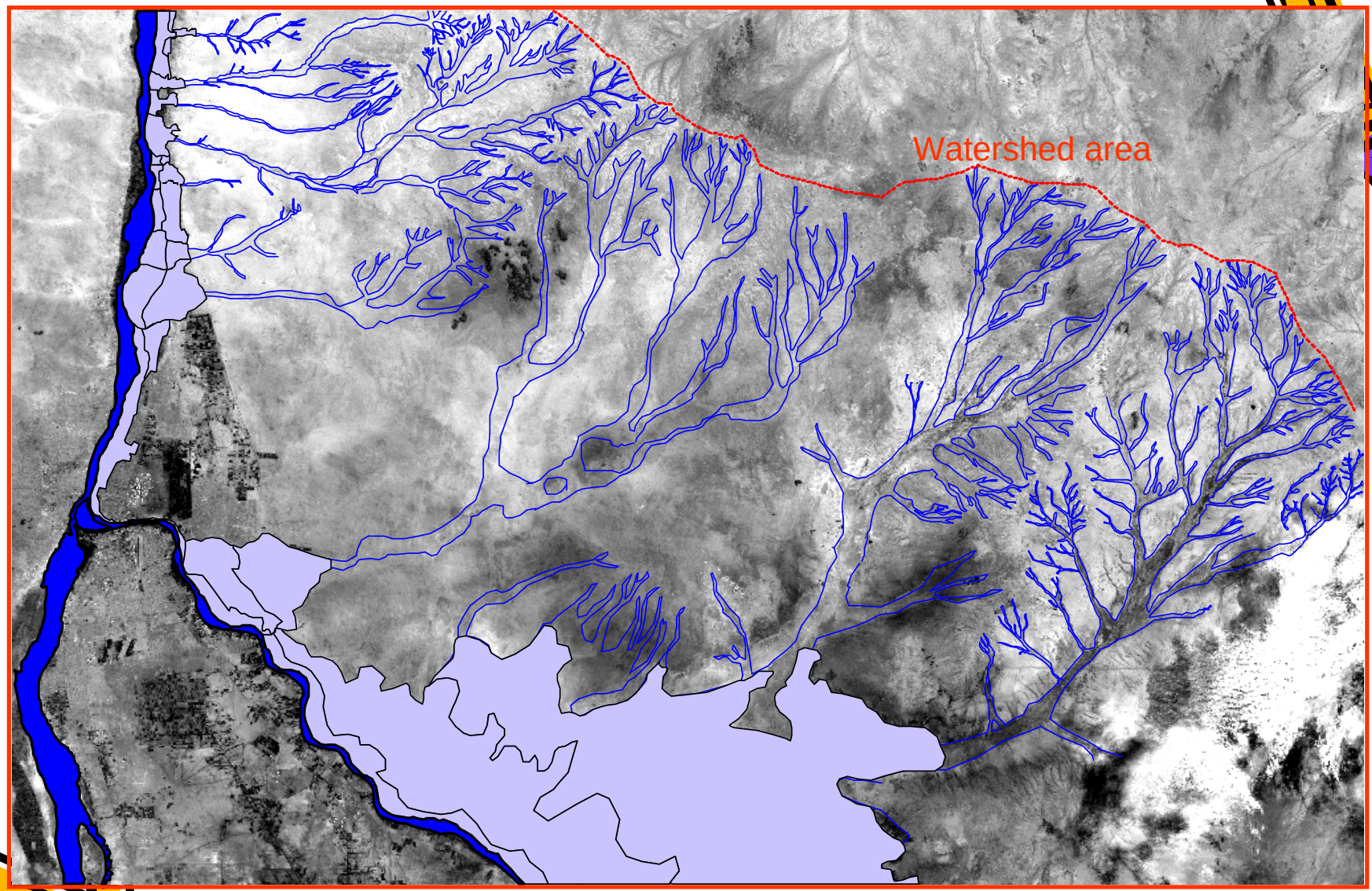
Findings

3. Remote Sensing

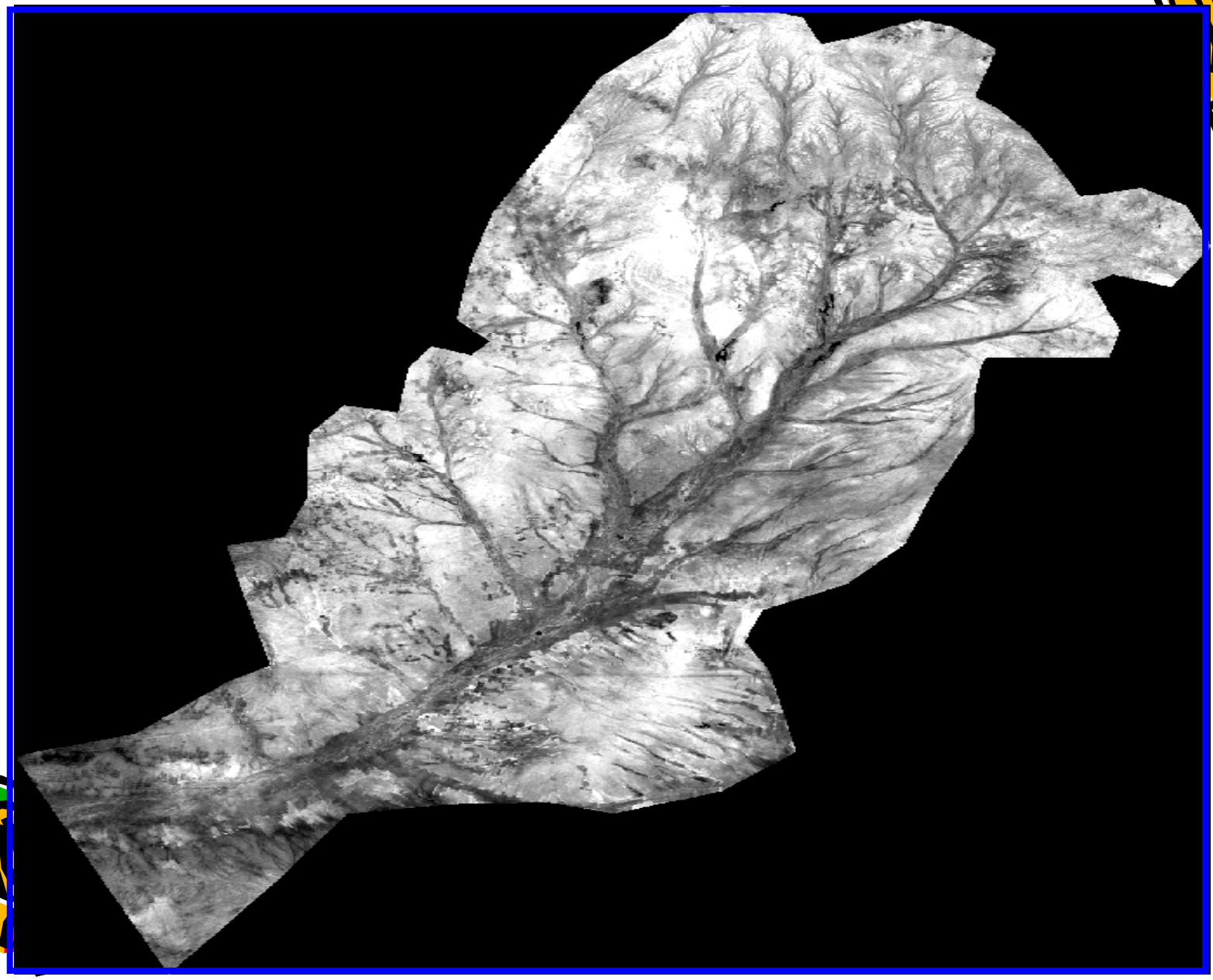
Landsat Thematic Mapper (TM) images for the years 1989, 1996 and Landsat ETM 2000 plus SPOT 1988 (hard copy) and 2000 (digital) were processed and interpreted. Useful information was extracted from this data.

Drainage System: Major permanent watercourse in the area is the Nile (Blue Nile and River Nile). Seasonal channels are called (Wadis). All Wadis in the study area flow towards the Nile. Most of the drainage type in the area are dendretic.

Drainage and Flood Prone Areas

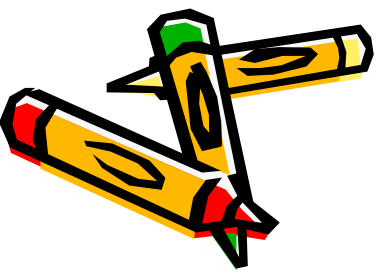


Dindretic Type Drainage

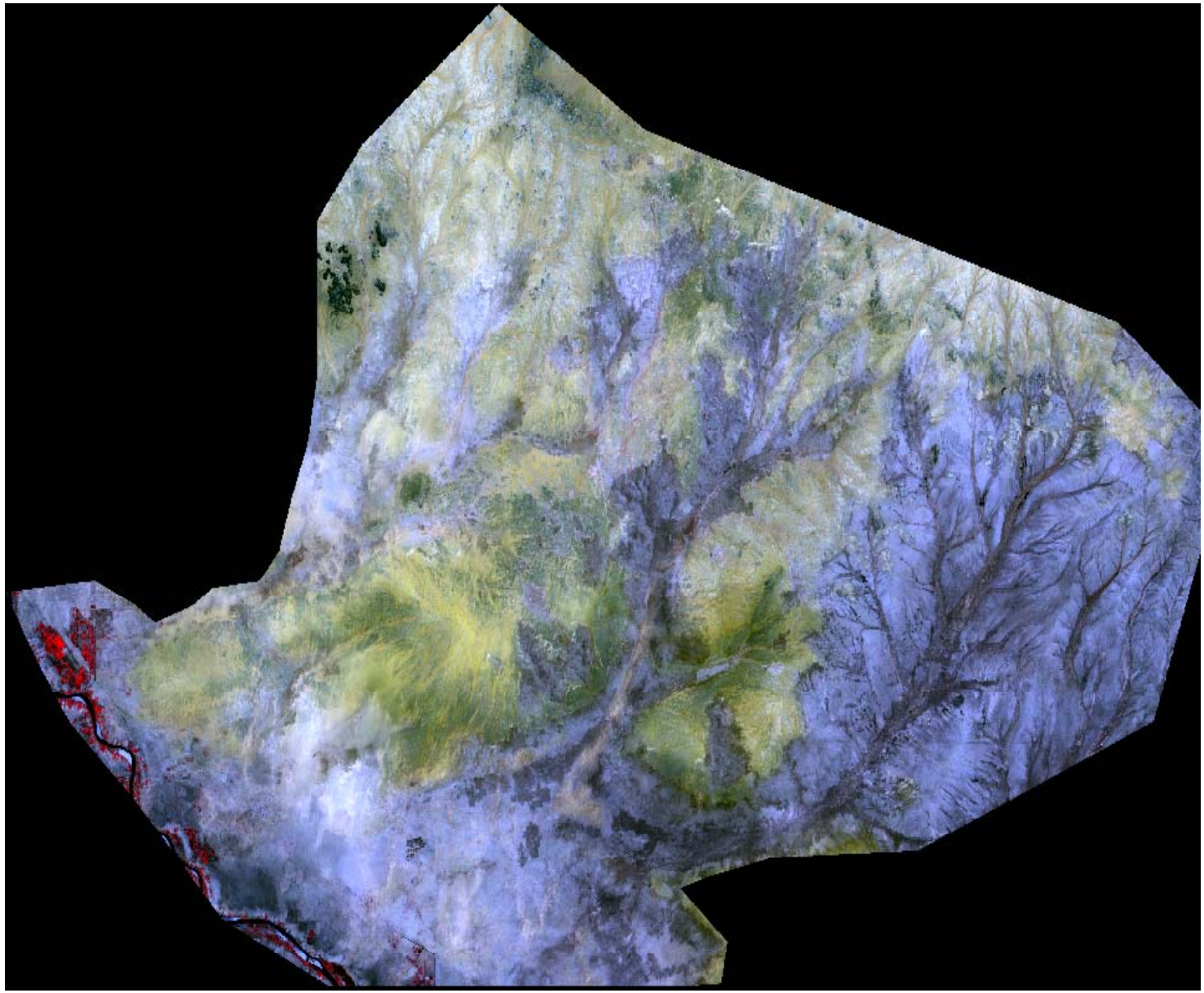


Findings

The morphology of Wadis in the area is that, they have many tributaries at upstream. Most of these tributaries are narrow and intensively distributed and represent good supplies for the main channel. While Wadis at downstream are one major shallow broad channels and in most cases finishes as a delta. These deltas are typical flood prone areas. The broadness and the shallowness of these Wadis ends or deltas made planners and politicians to make their minds to use them for houses and agriculture.



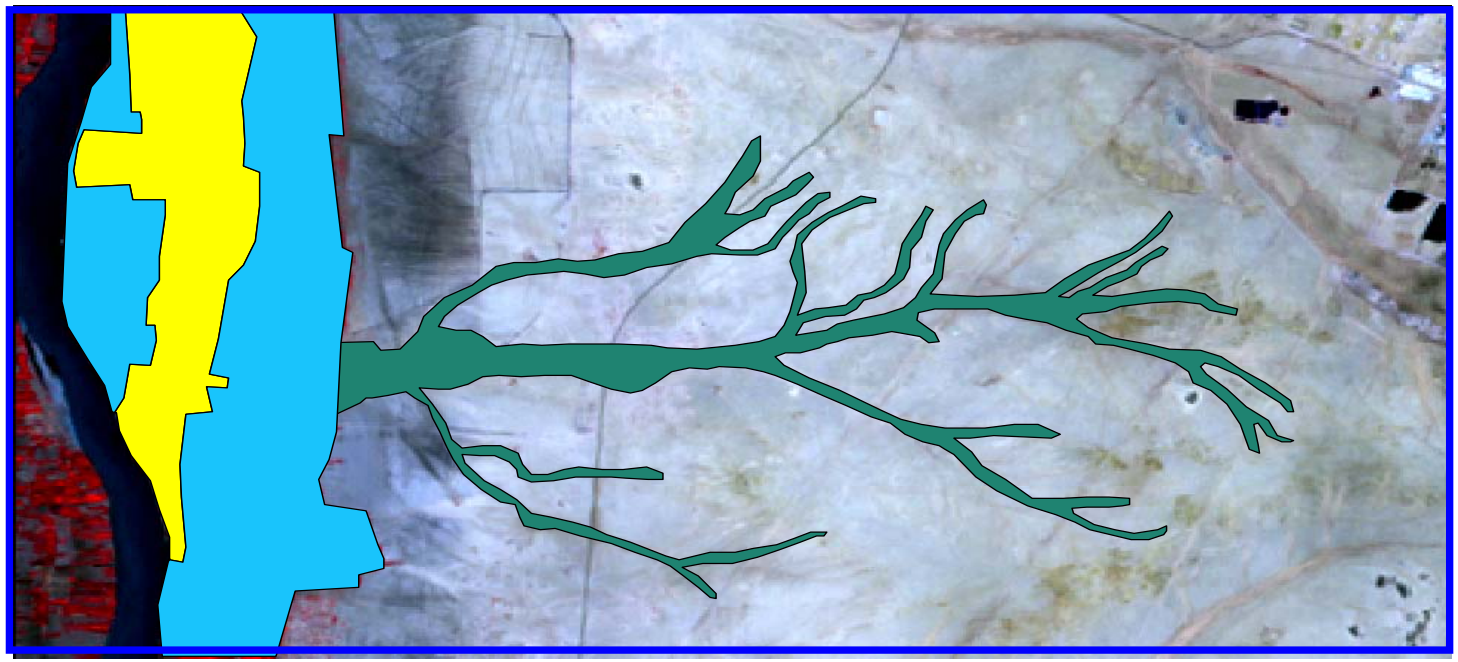
Tributaries and Deltas



Findings

Landuse: About 80% of the area are devoted for rangelands. Vegetation type is semi arid and classified as sparse. Some dense spots were noted in Wadis, some of them could be classified as forest. Area along the Nile dominated by settlement and cultivation. Recent imageries of 2000 and 2001 showed that the residential area expansion at the expense of the cultivated areas compared to 1980s and early 1990s. Cultivation was mainly distributed fertile clay deposits in the area. This soil type only found in flood prone areas and inside Wadis basins. This why most of cultivation vulnerable to damages and destruction. The same could be said to some recent constructions, but in general settlements in the area also are vulnerable for environmental hazards (floods). Jeili town is the most susceptible area for floods in 1988, 1998 and 2001, Jeili town witnessed severe destruction for buildings and settlements. This was due to Jeili Wadi crosses the town and farms from east to west.

Jeili Town and Surrounding Cultivation



Jeili Town

Cultivation

Wadi Jeili

Most vulnerable area for floods. Buildings and cultivation at Wadi Jeili flood prone area.

Findings

Landuse: Jeili refinery was also constructed on an environmentally risky area. It was constructed on the upstream of the Wadi so it is not vulnerable to severe floods attack. The refinery buildings blocked some tributaries that might cause a small destruction.

Some villages in the southern part of the area were located inside Wadi courses. These villages rarely struck by flood because by local knowledge villagers selected high spots to build their homes. Sometimes they construct soil barriers to secure homes.

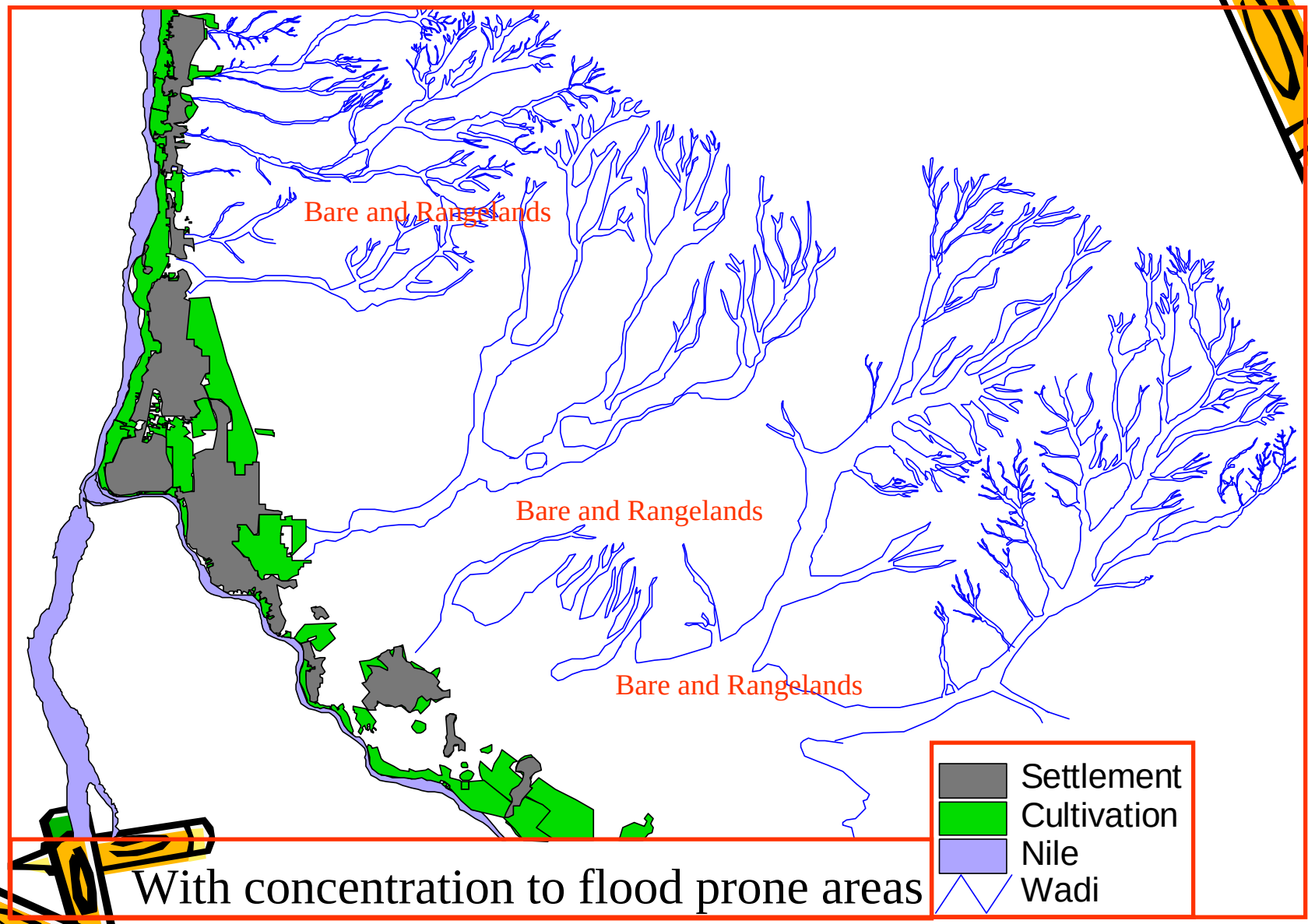
Plantation Constructed on Risky Area

(Jeili Petroleum Refinery)

Jeili Refinery

Small risk at upstream only some small tributaries blocked

Landuse



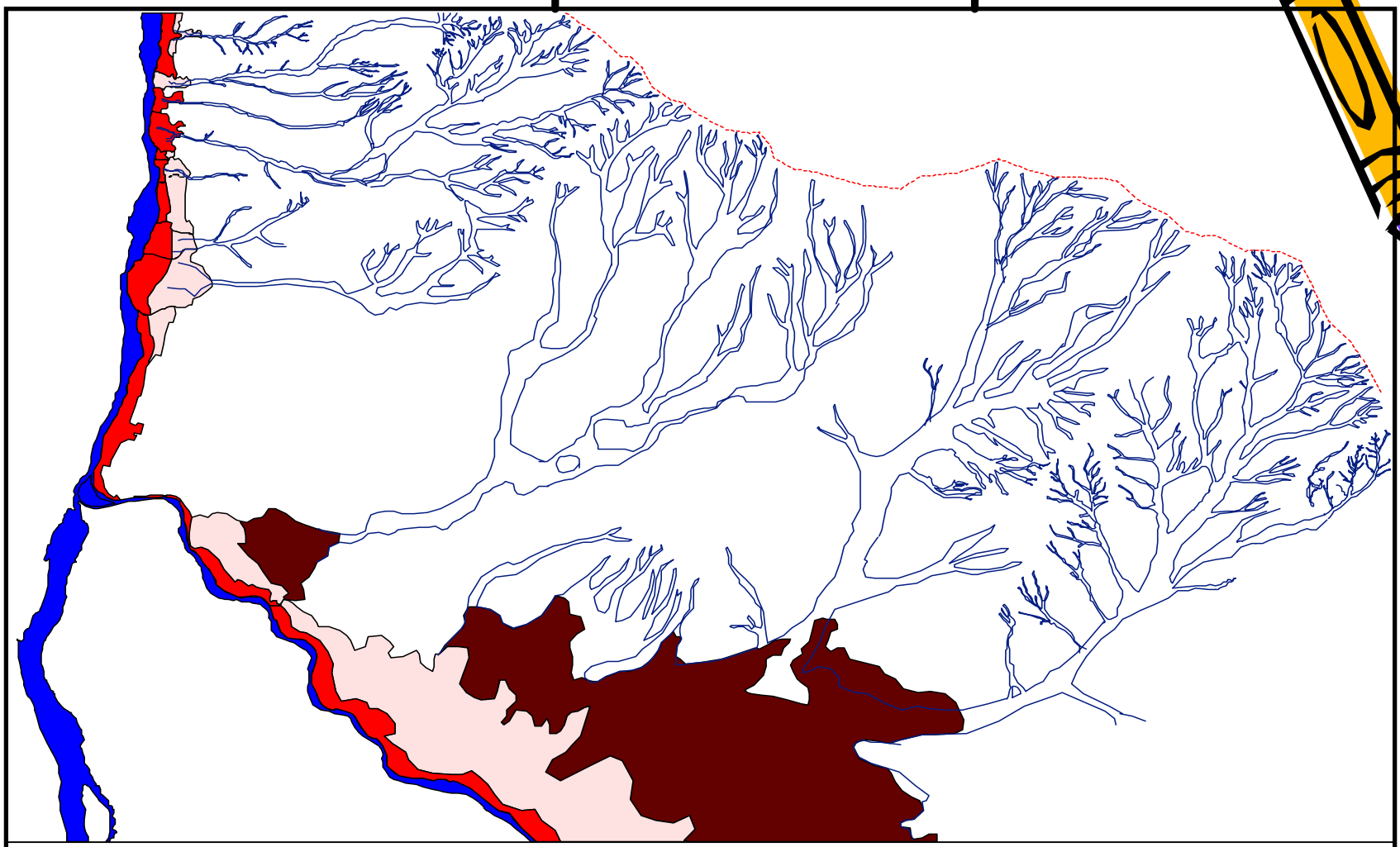
With concentration to flood prone areas

Findings

4. GIS

Simple GIS is used. Landuse, drainage system, flood prone areas maps and data supplied from visits were utilized in the GIS system. Simple risk map is produced with reference to flood.

Simple Risk Map



High risk areas always near the Nile.Very low risk at Wadis prone areas only

Discussions

Climatology there is a small change in the climate of the area for the last two decades since 1988 up 2003. The annual rainfall amount some times exceeds normal averages of the area. Floods occurred twice in three years in 1998 and 2000. More destruction and damage expected to the risk areas (flood might be expected this coming season 2004).

The dramatic population increment in the area represents a real problem because settlements expand on areas totally classified as risk area due to floods. Decision makers and planners are completely aware but no actions were taken.

Base Maps and Thematic Maps: small scale data available for the area is not enough to produce detailed information for planning and replanning. The only base maps produced by the Survey Department in the Sudan were old and small scale. Remote sensing technology was not potentially utilized to solve this problem. In spite of the fact Sudan has a Remote Sensing Institution since 1980s.

Discussions

Recently there are many governmental and private institutions deal with remote sensing and GIS technologies in the Sudan. The problem is that every unit operates in an isolated island. In summary the major components worked together to produce this situation in the area could be itemized in that, towns and cultivated areas were located at flood prone areas. New methodologies and tools, such as the integration of the different approaches, remote sensing, and GIS were not utilized. Finally not only the Nile flood is the destructive factor, but also Wadis strongly contribute to the destruction, too.

Conclusion

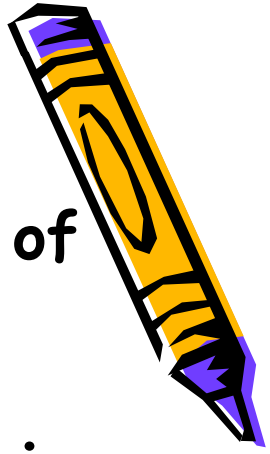
Space-borne data, utilized in the study, were visually and digitally interpreted. The geomorphological hazards with reference to floods have been assessed. The study showed that an area extends as a belt along the Nile is subject to floods.

Wadis flow from the east towards the Nile incorporating flood at down stream.

Major human activities such as settlements, cultivation, plantation, and other buildings were constructed at the flood prone areas, which are classified as environmentally risk areas.

The utilization of geo-information for assessing and evaluating geomorphological hazards is of great benefit.

Recommendations



The study recommends that intensive utilization of geo-information augmented with other environmental data will help in producing recent base and thematic maps. Those maps could help in producing a sound landuse map for the area that definitely considers the flood prone and risk areas.

Some of the areas classified as high-risk areas could be devoted for urban forestry. As the urban area lacks such recreational areas.

Rapid assessment for the environmental hazards in the area is required. As the severe destruction could be expected during every rainy season.