Flood Analysis in the Blue Nile, a Case Study of Flood Simulation in Khartoum with Climate Change Scenarios

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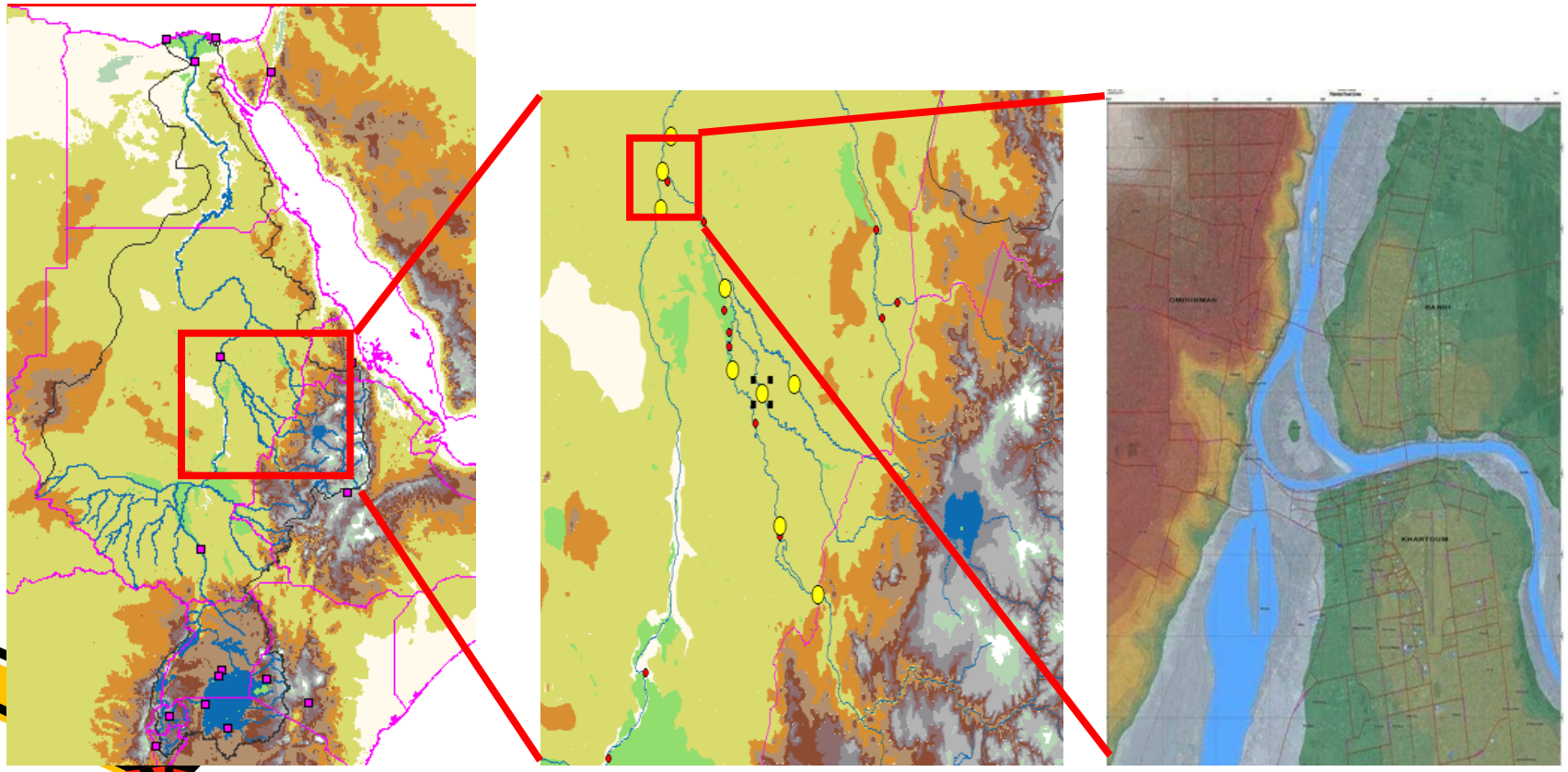
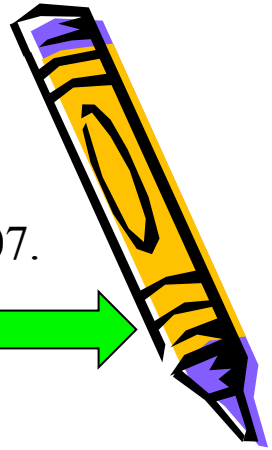
Background Information

- The Climate varies in Sudan.
- The rainy season (Jul. to Sep.).
- The annual rainfall is 1800 mm, and 80 mm in Khartoum.
- The Blue Nile contributes with around 67% to the discharge of the main Nile.

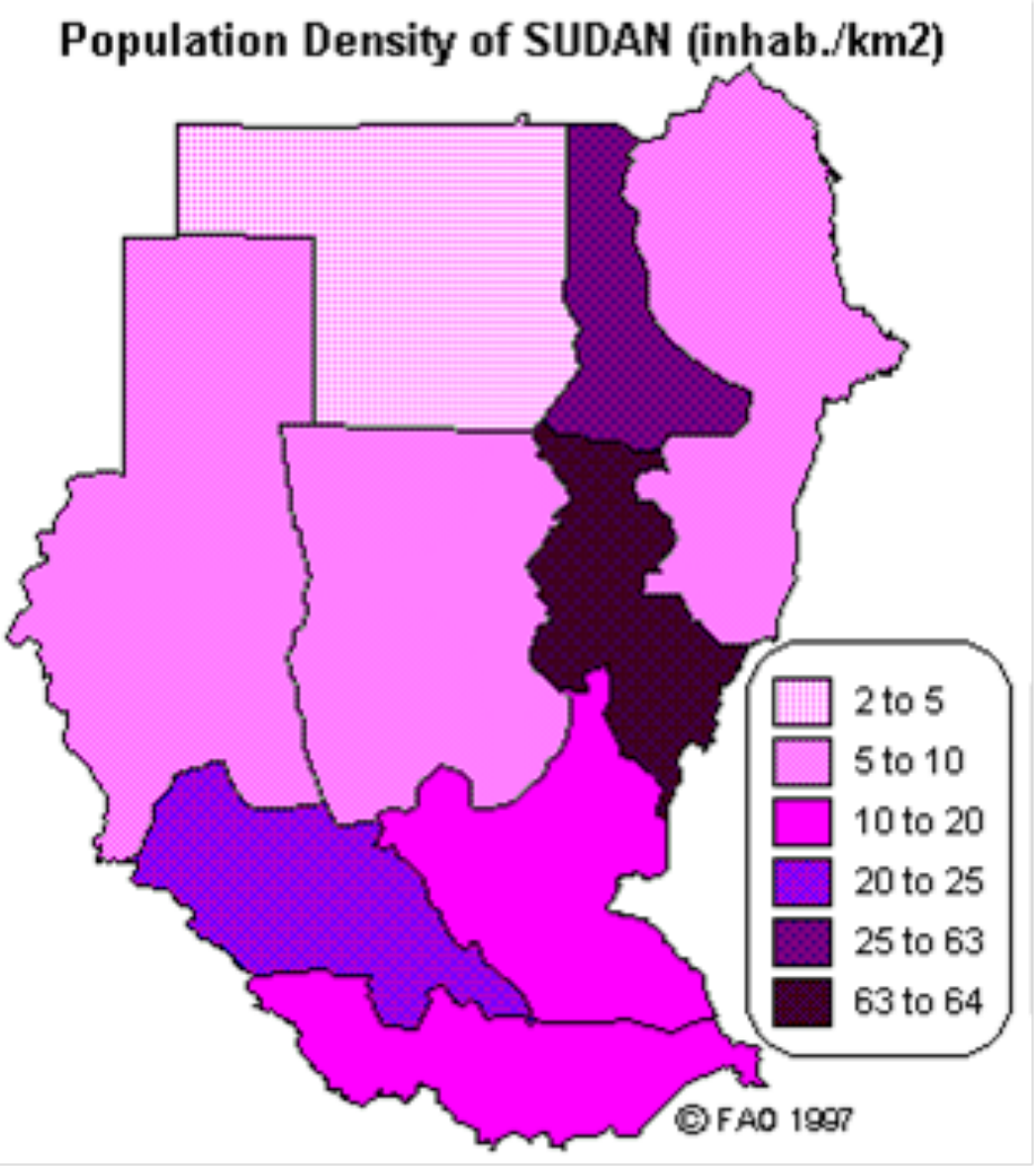


Problem description



- Flood hit Khartoum many times in recent years 1999,2000, 2001, 2006, 2007.
- 70% of the area of the country is situated with in the Nile River catchment
- The damage resulting from the 2007 flood in Khartoum State alone was estimated by more than 45 million US dollars.
- The people along the White Nile in Khartoum are the people who suffer regularly from flood (Blue Nile blocks White Nile).
- The current FEWS in Sudan(FEWS, Delft Hydraulics 1992) suffers from many problems (forecasting the time of the flooding).

This research is intended to contribute to better management of future floods in order to reduce flood damage and the number of people affected.



Population density in Sudan. (Elduma, 2004).

Methodology

Water balance in the Blue Nile

GIS for topographical map

Arc Hydro Tools for DEM

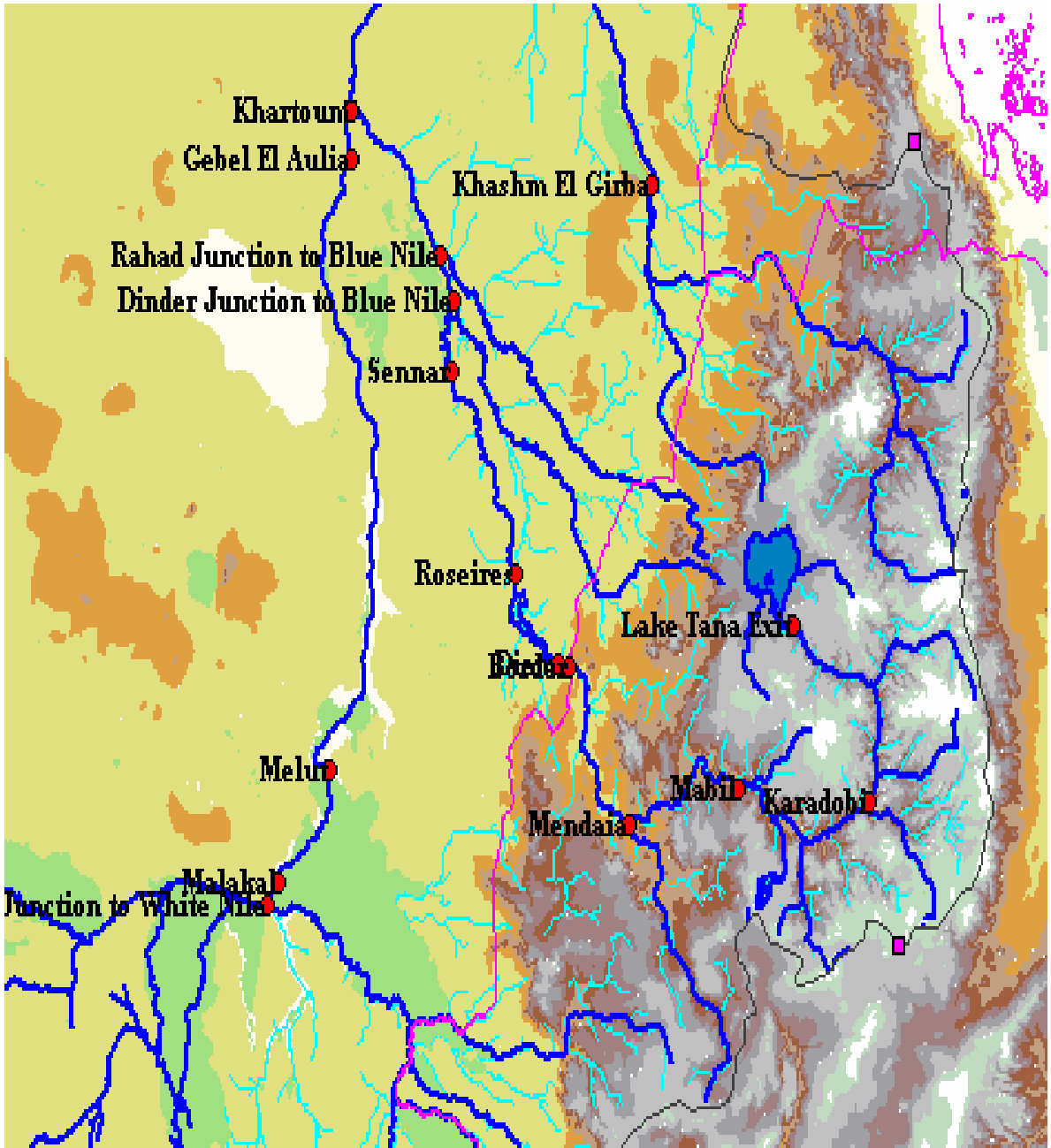
2D model (SOBEK) for Khartoum

Extracted the model result to GIS

Model result and RS image compared.

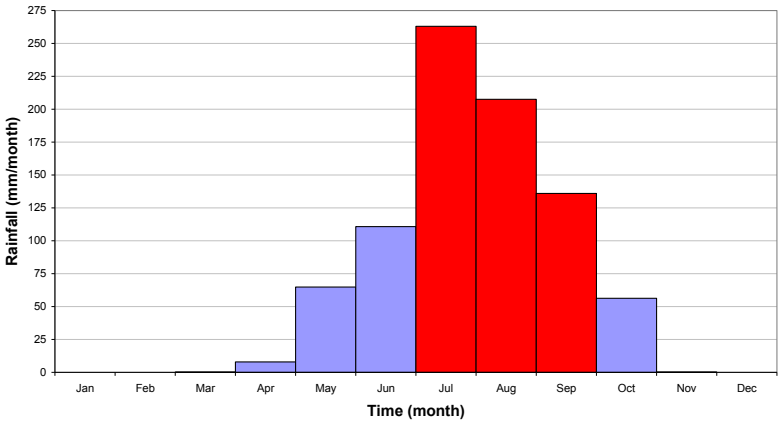
Different scenarios for climate change

Data

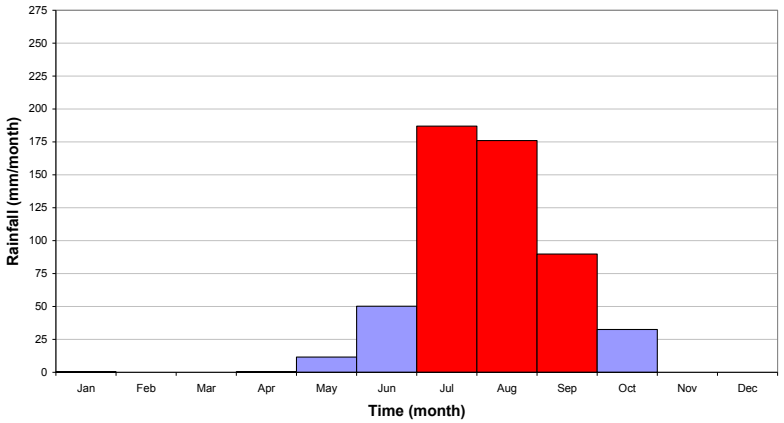

Khartoum
Gebel El Aulia
Khashm El Girba
Rahad Junction to Blue Nile
Dinder Junction to Blue Nile
Sennar
Roseires
Lake Tana Exit
Melut
Mabil
Karadobi
Mendaia
Malakal
Junction to White Nile

Flood analysis

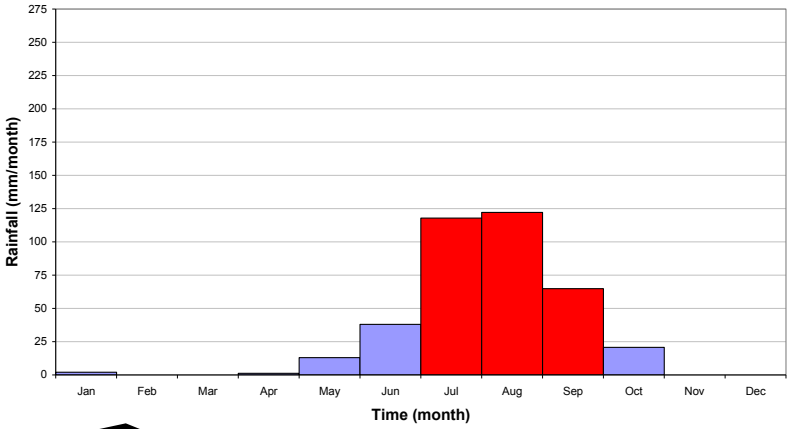
Monthly average of Damazine (Rossieres) rainfall from 1999 to 20007



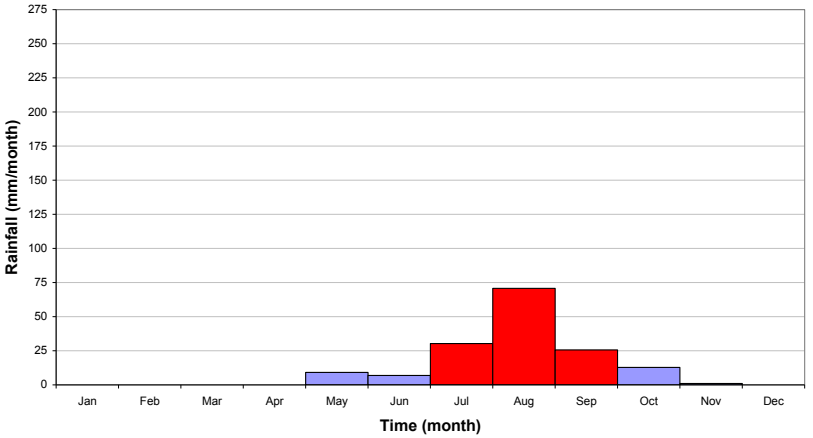
Monthly average of Sinnar rainfall from 1999 to 20007



Monthly average of Medani rainfall from 1999 to 20007



Monthly average of Khartoum rainfall from 1999 to 20007

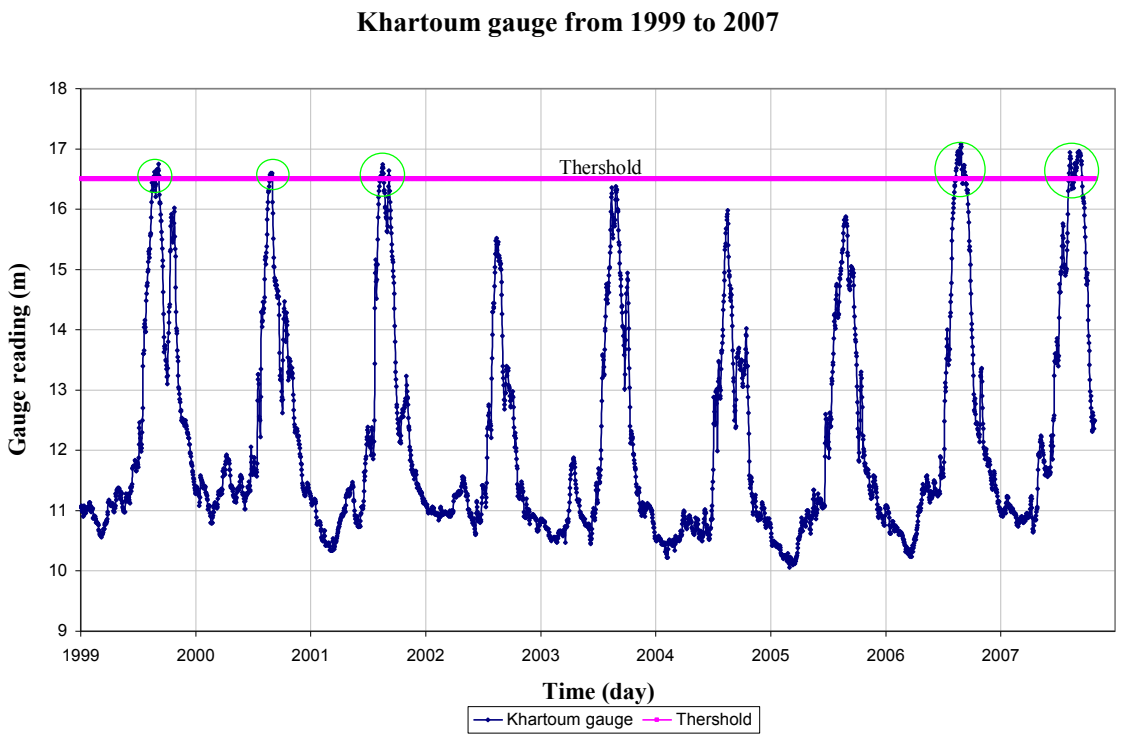


The highest rainfall occurs during Jul. Aug. and September.

River flood accompanied by local rain fall occur in Aug. in Khartoum. 7

Flood analysis

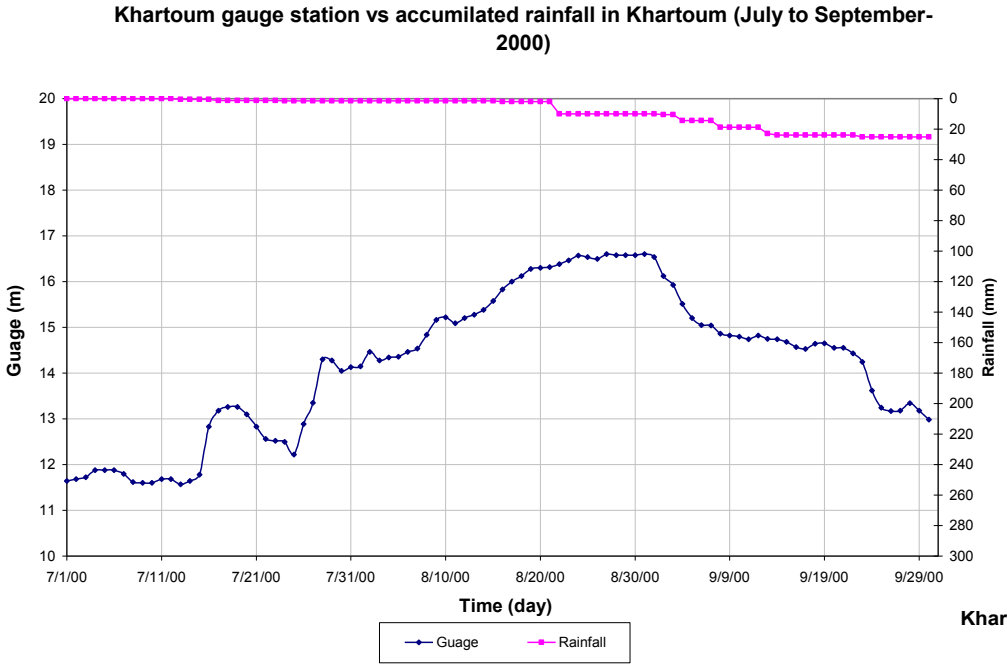
Warning	Alert (m)	Critical (m)	Flooding (m)
Water level	15	16	16.5



The threshold of the flood in Khartoum is 16.5m.

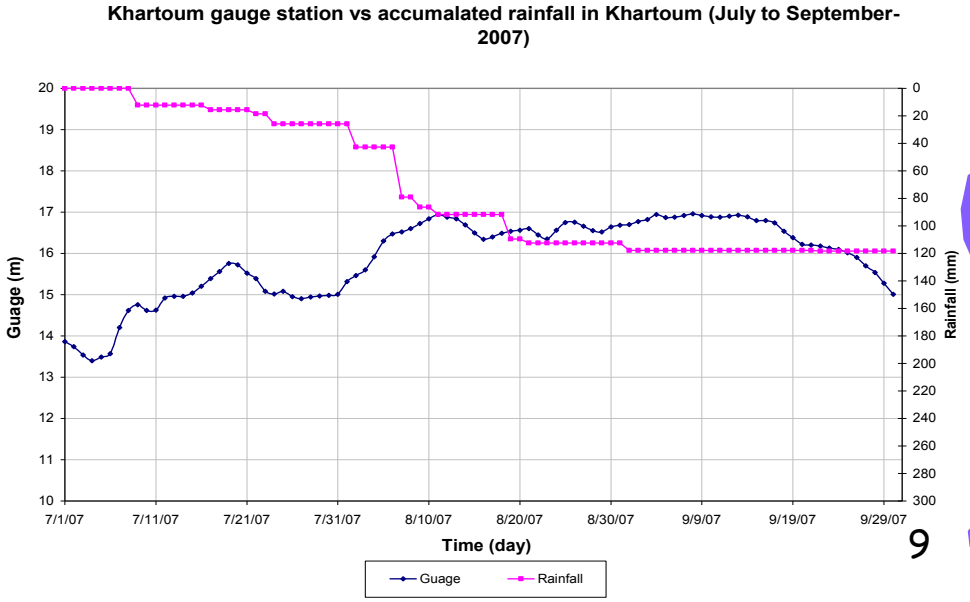
The river flood in 1999, 2000, 2001 2006 and 2007.

Flood analysis

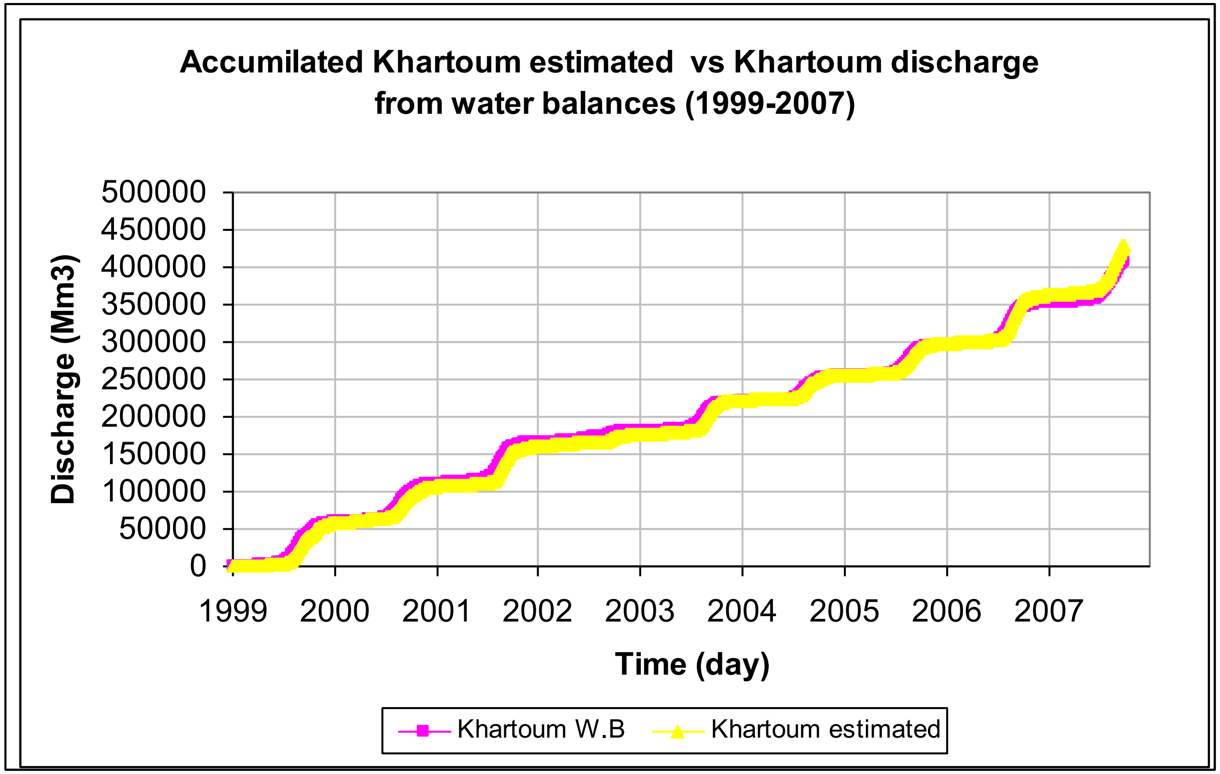


The year 2000 is river flood

The year 2007 is river flood accompanied by local rainfall.



Water balance

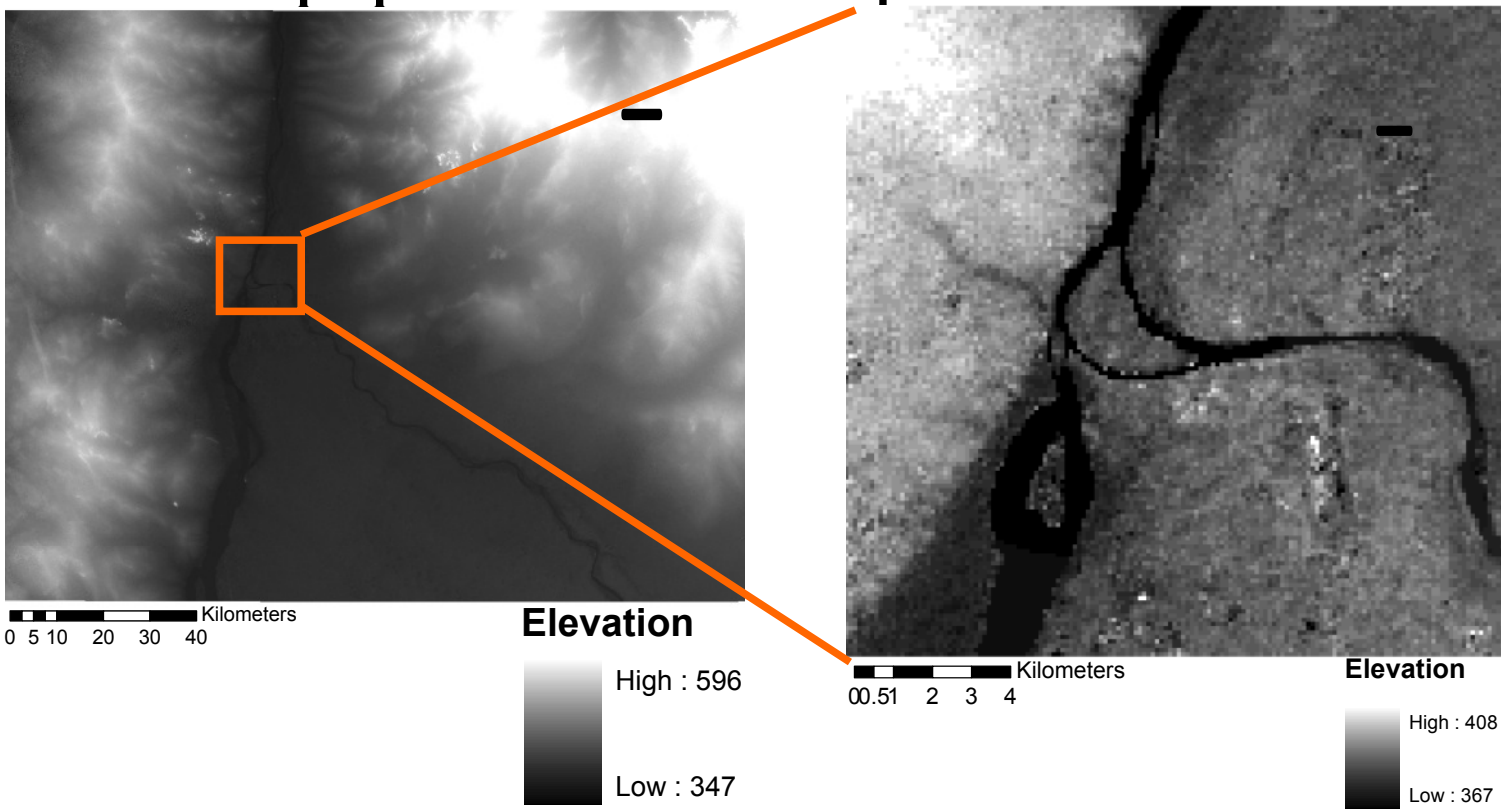


Qcomp_R - AbsGM - Abs_Proj - QR - Evap + Rainfall = QBal_S

Qcomp_S + QRD = QKhrt

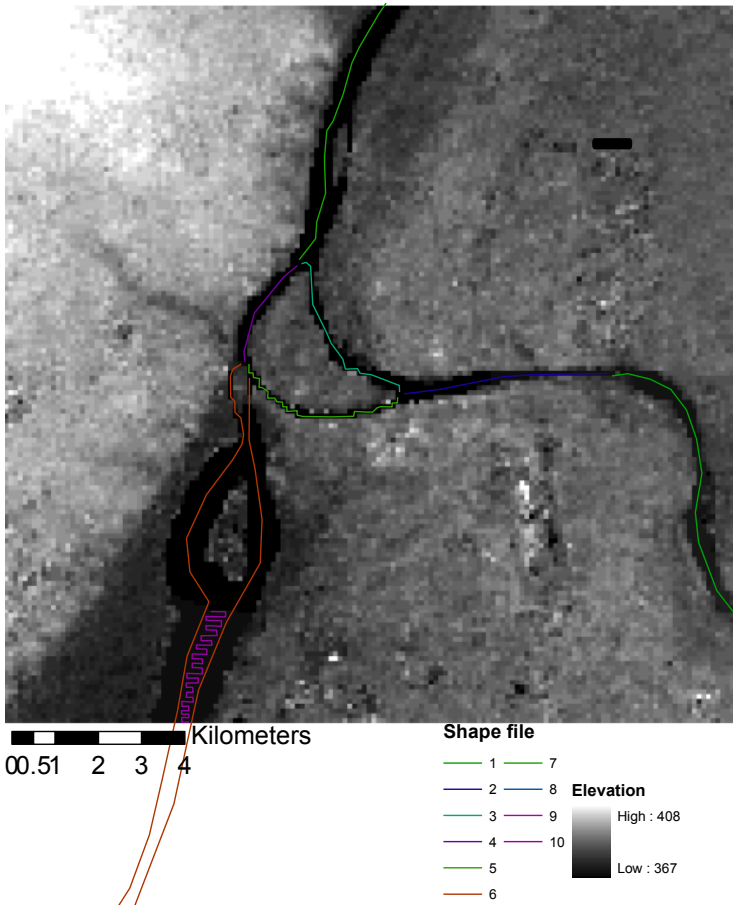
Build the 2D model

Down load and preparation of SRTM map



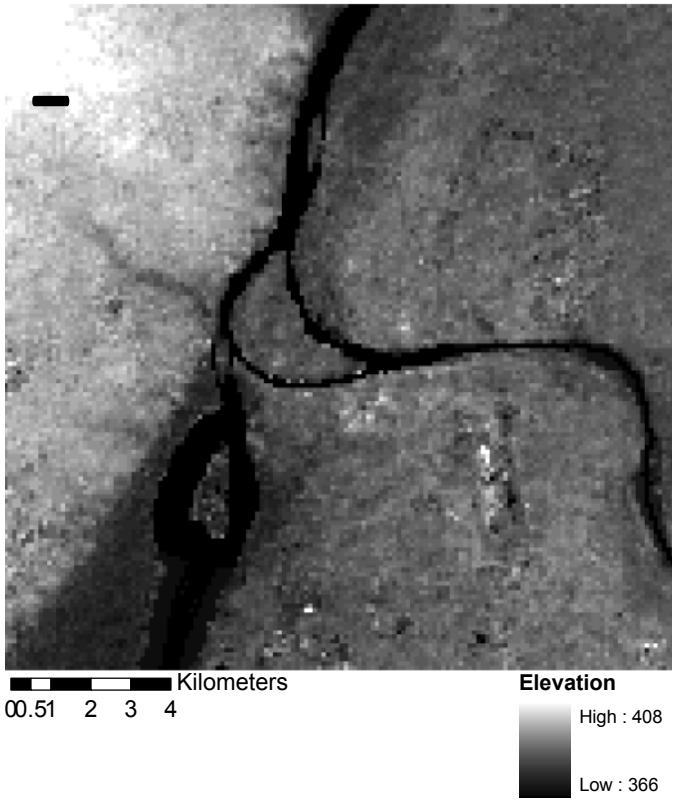
- Down load SRTM map (http://www.ambiotek.com/srtm).
- Georefrence the map.
- Clip the desired area (Khartoum)

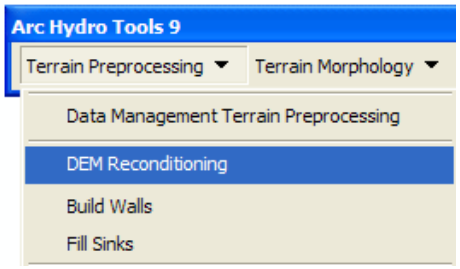
Build the 2D model

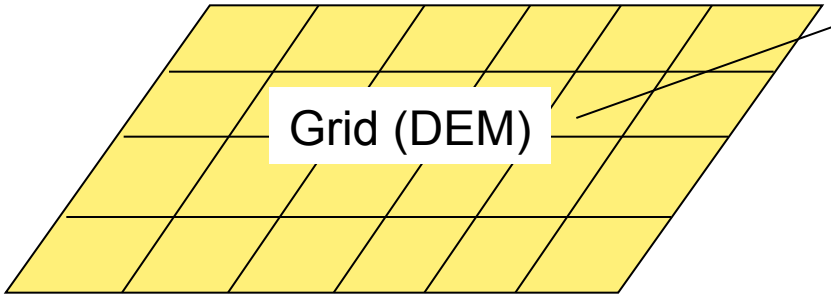


Lowering the elevated SRTM

- Create shape files for the river cells.
- Use Arc Hydro Tools.



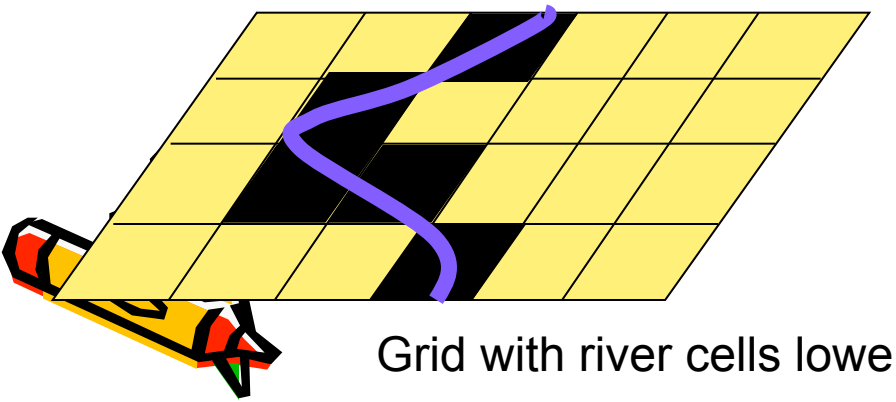




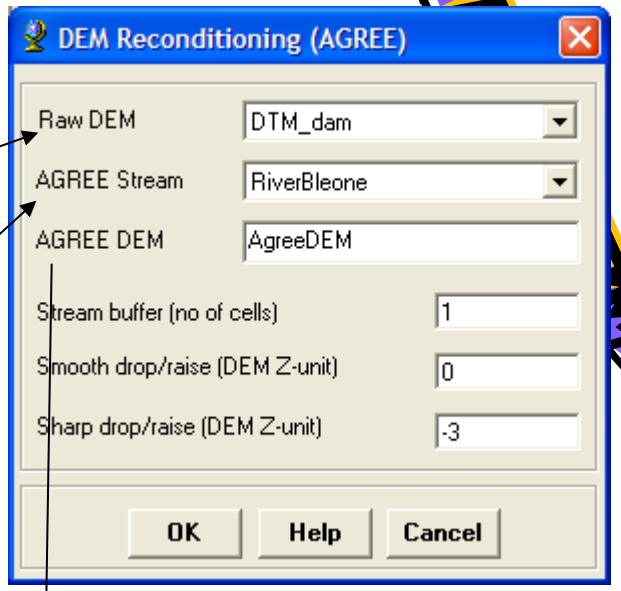
+

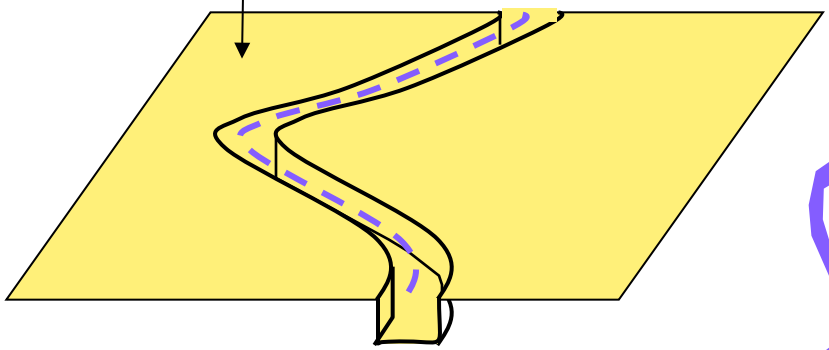
Polyline of the river edge (Shapefile)

=



Grid with river cells lowered





Conceptual result (AgreeDEM)

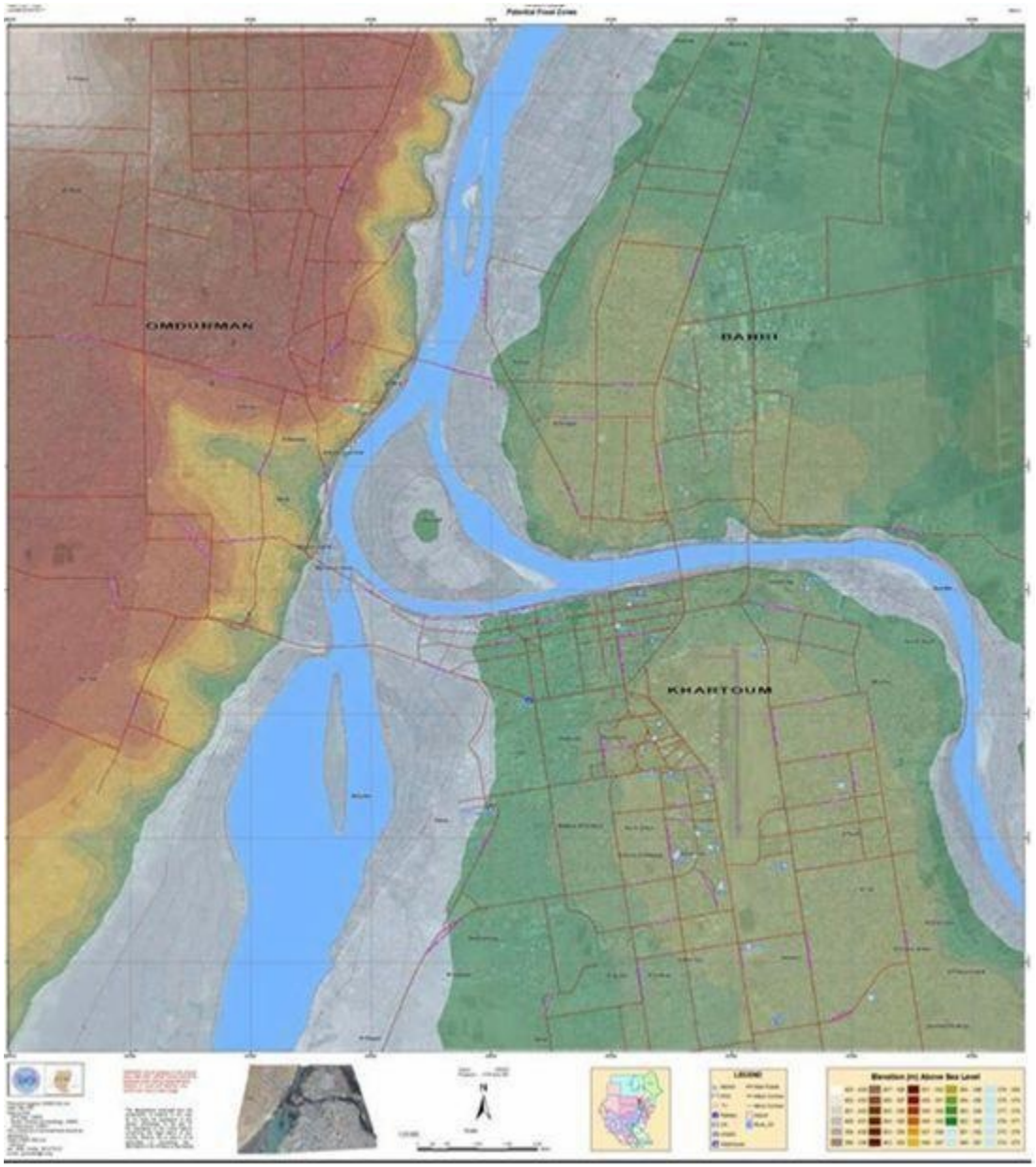
Build the 2D model

Topographical elevation map for Khartoum

- Topographical map
- Digitized C.L
- Shape file to TIN
- Overlaid C.S
- Digitized cross sections
- Embedded cross section
- TIN to Raster
- Raster to ASCII

Image of topographical map

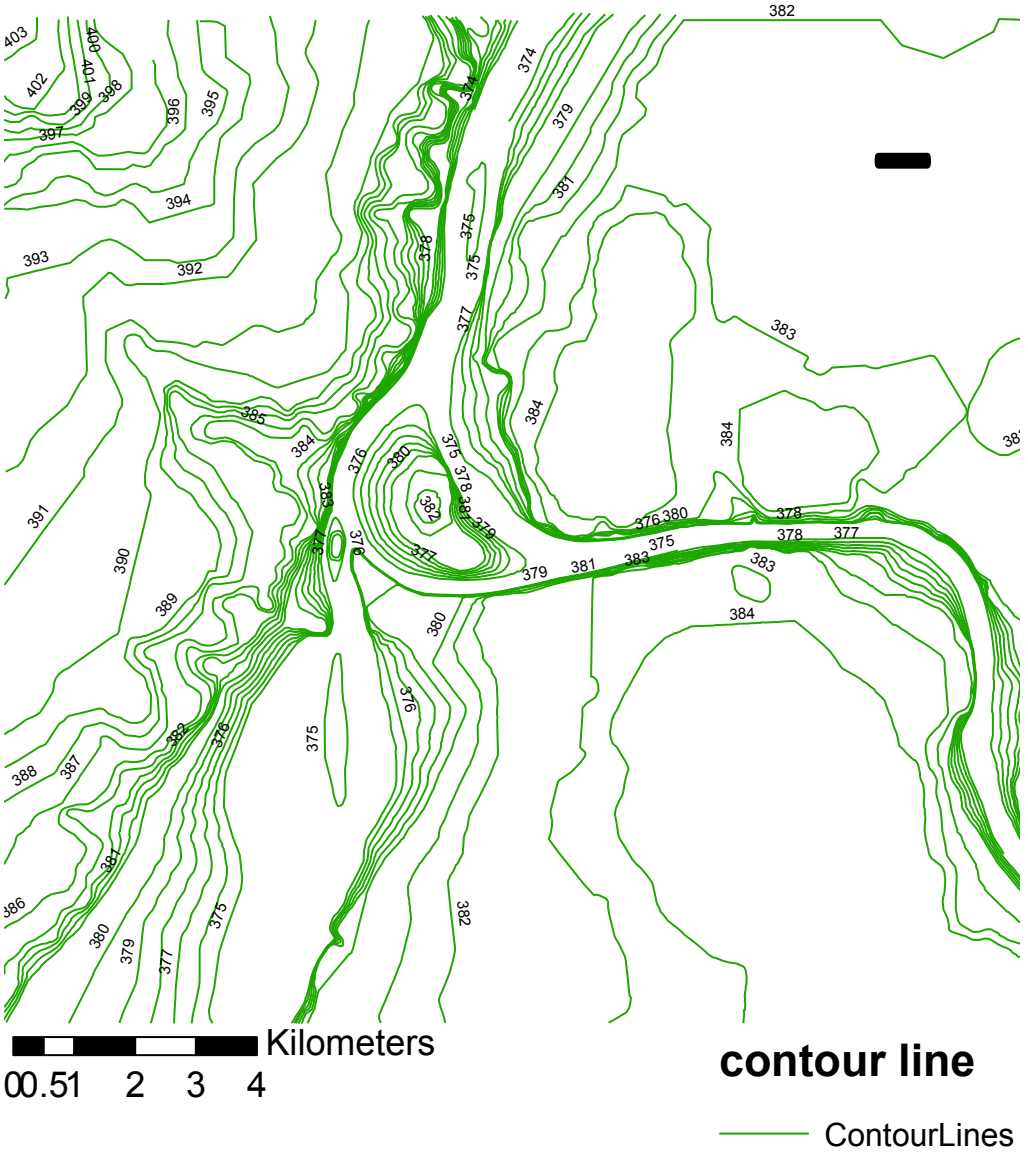
- Download the map.
- Georeferenced the map.



Digitized contour lines of Khartoum

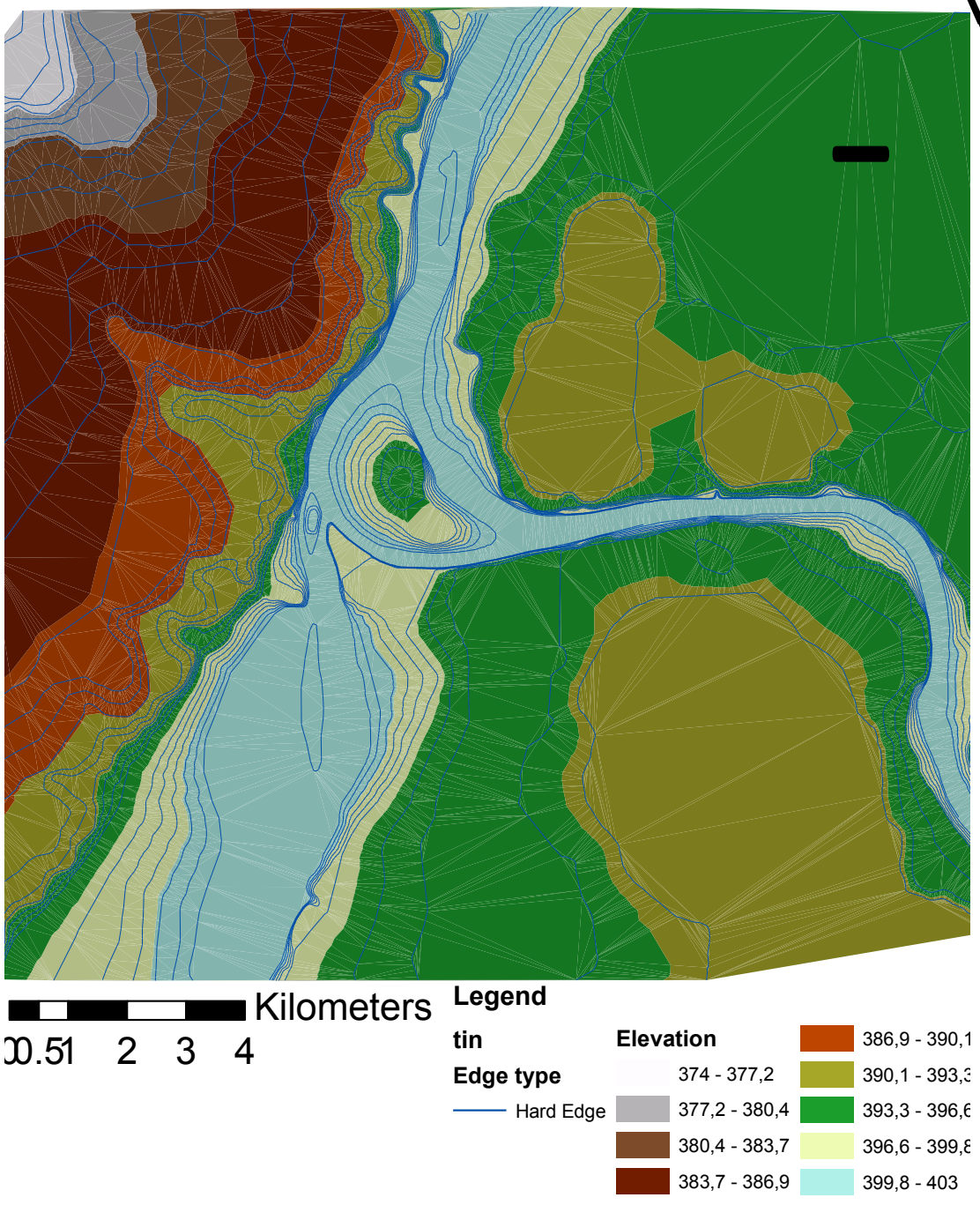
- Create Shape file.
- Add elevation.

67 contour lines.

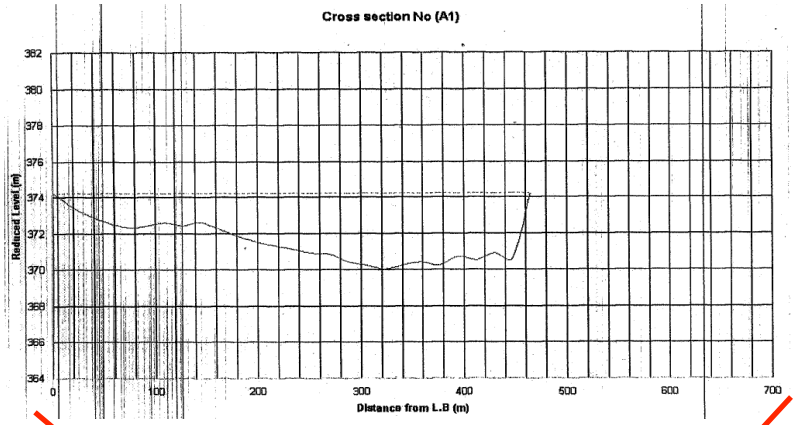


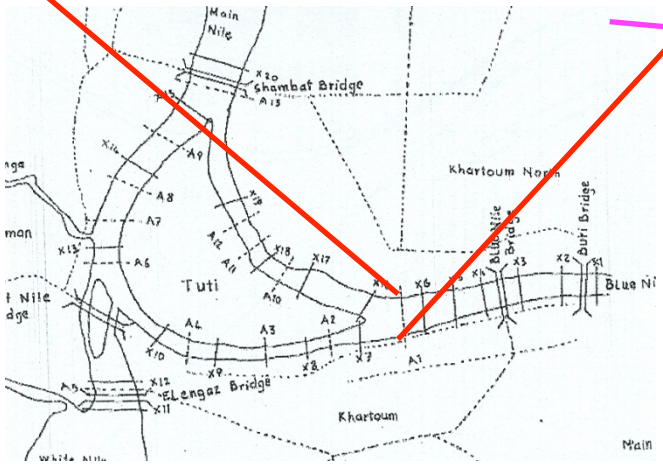
Convert the shape file to TIN

- Create TIN from feature.

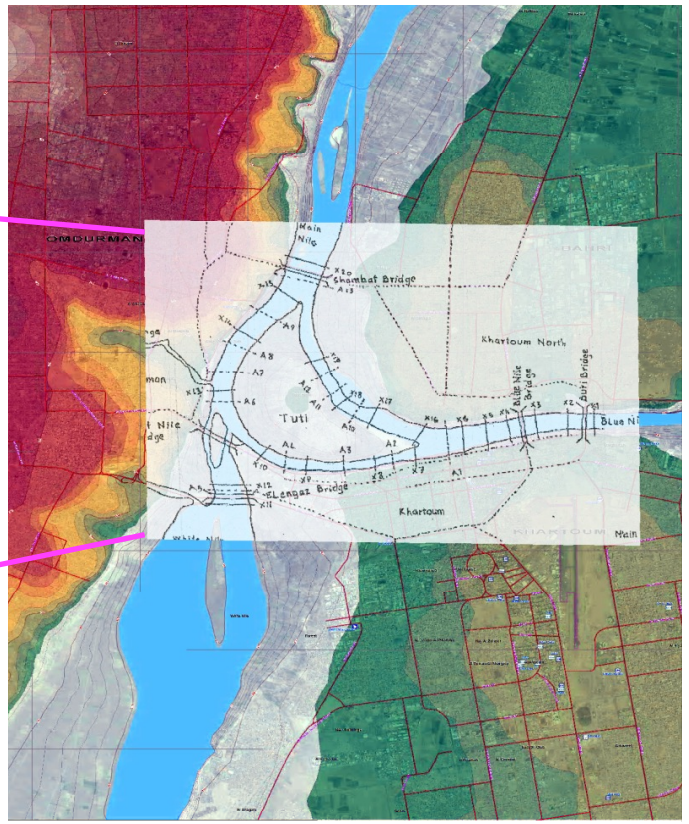


Overlaid the cross sections on the topographical map





- Add the map from UNESCO_Chair_for_Water, (2002).
- Georefrenced.

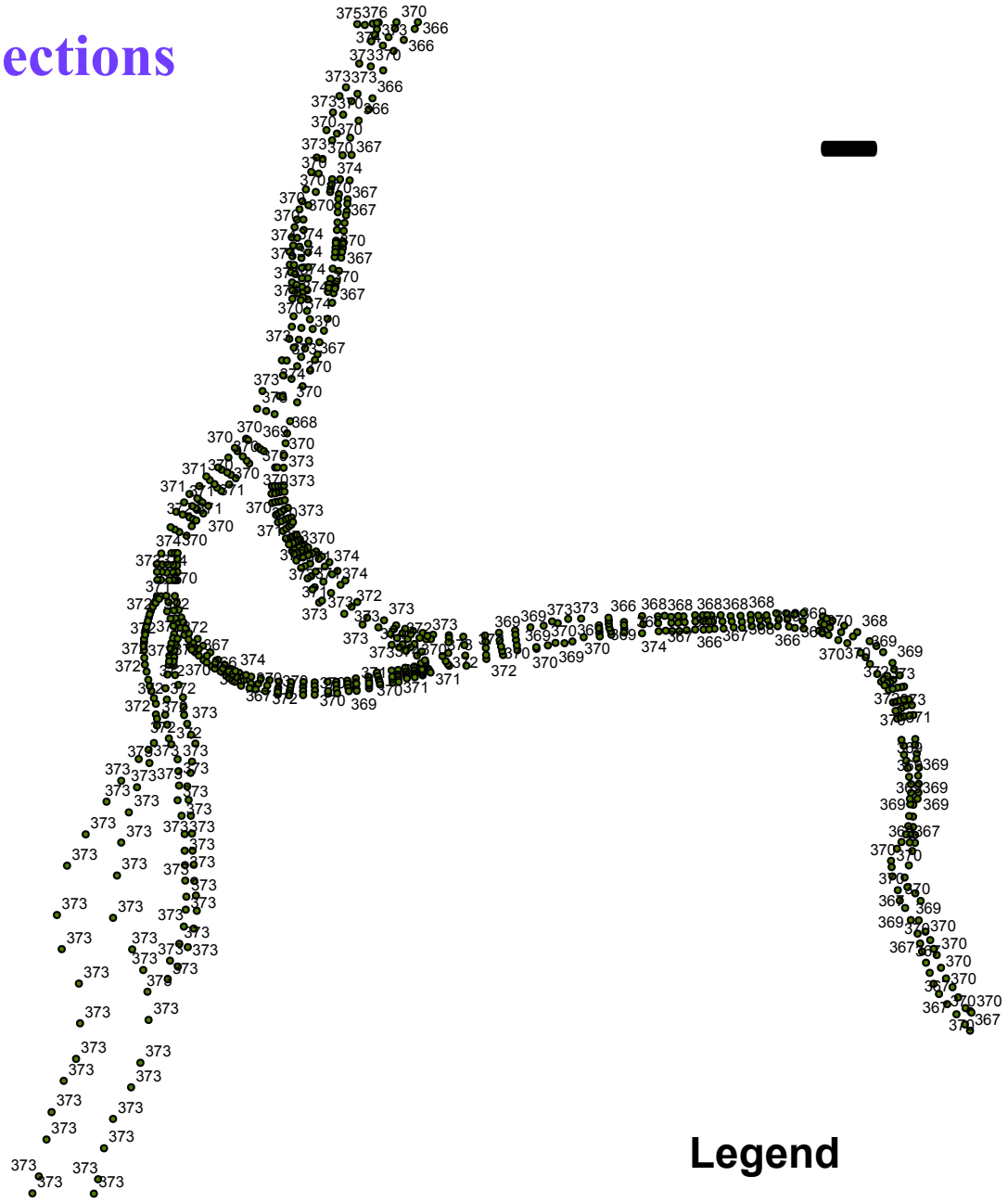


- 20 cross sections.
- 13 auxiliary cross sections.

Digitized cross sections of Khartoum

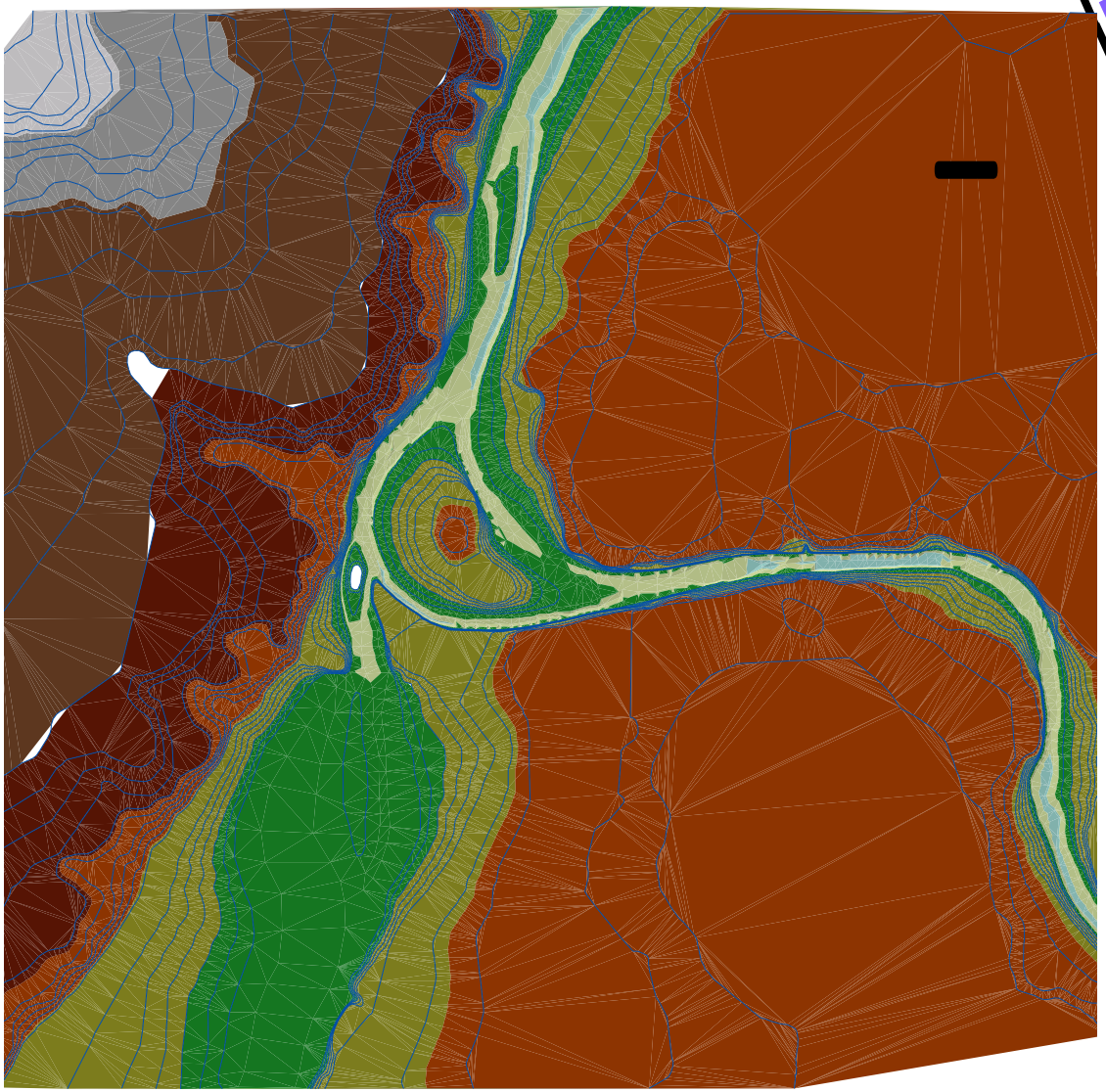
- Create Shape file.
- Add elevation.

803 points.



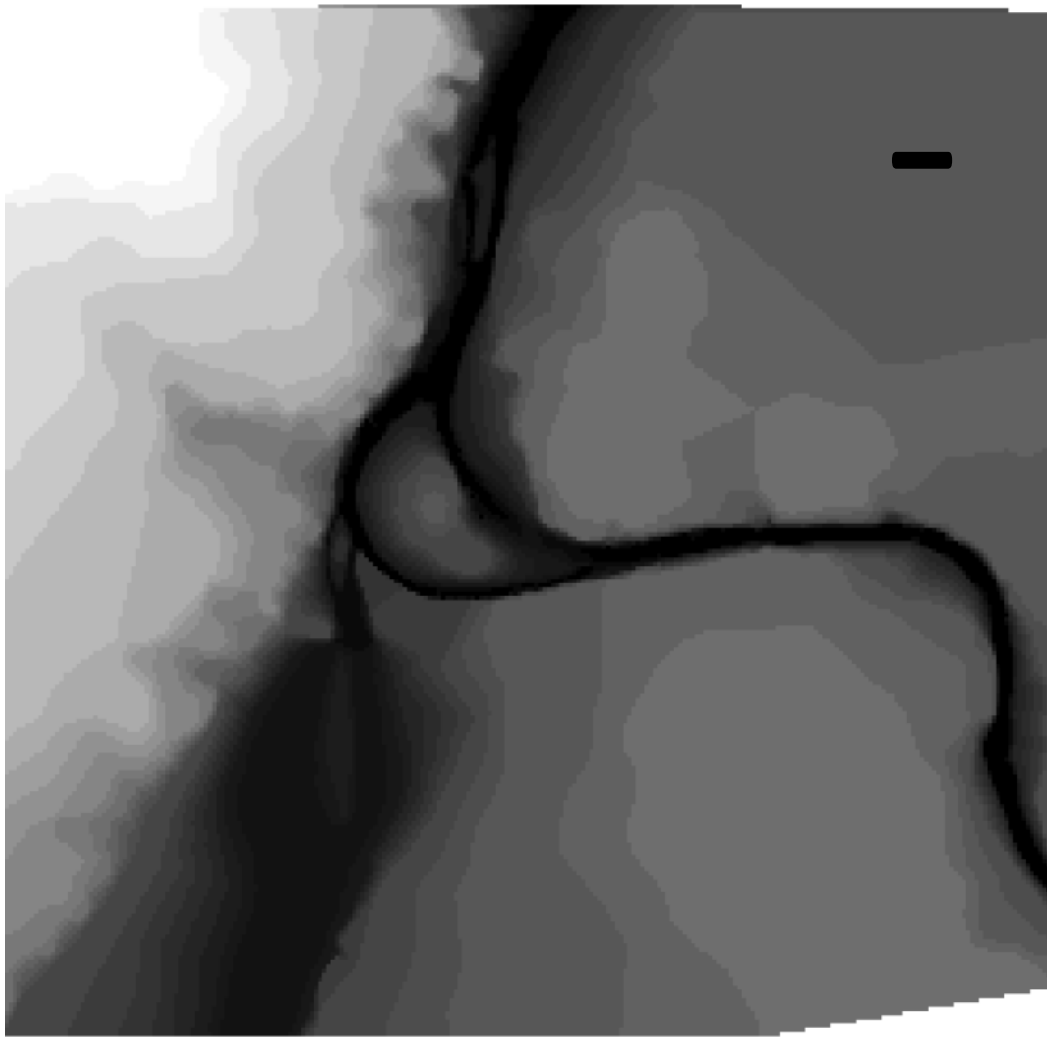
Embedded the cross sections on the TIN

Add Features to TIN



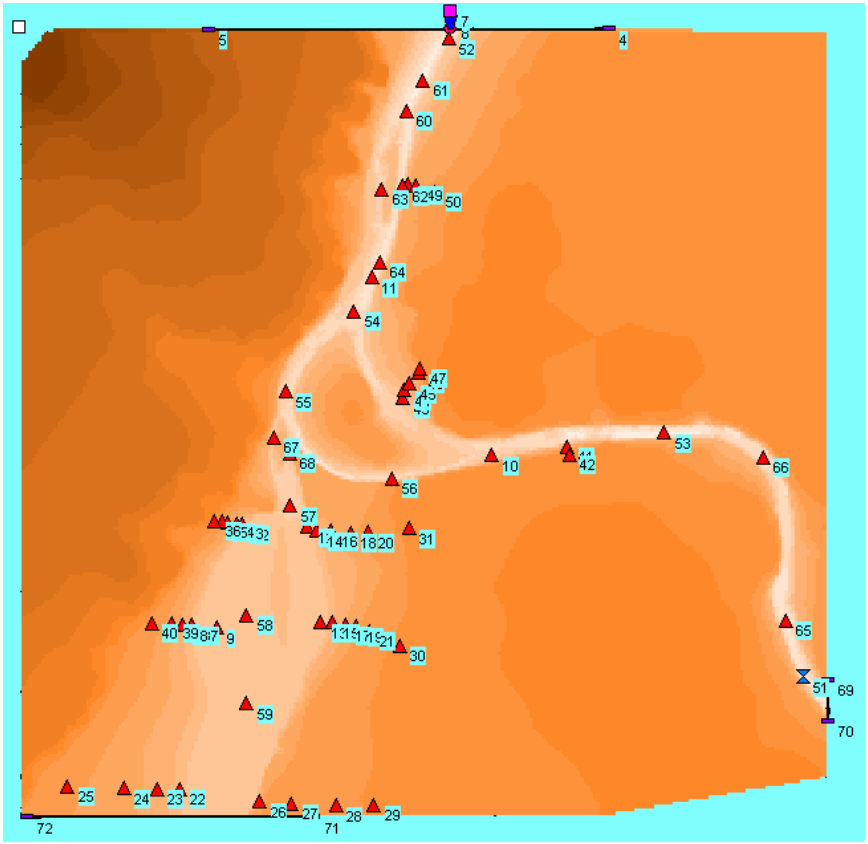
Convert TIN to Raster

- Covert TIN to Raster.



Build the 2D model

SOBEK 2D model by using elevation topographical map



Settings of the model

- simulation time step 1 day.
- simulated period (Jul. to Oct).
- out put is a daily time step.
- DEM map.
- Chezy = 40.
- **Upstream boundary condition:**

1. Blue Nile (Q).
2. White Nile (Q).

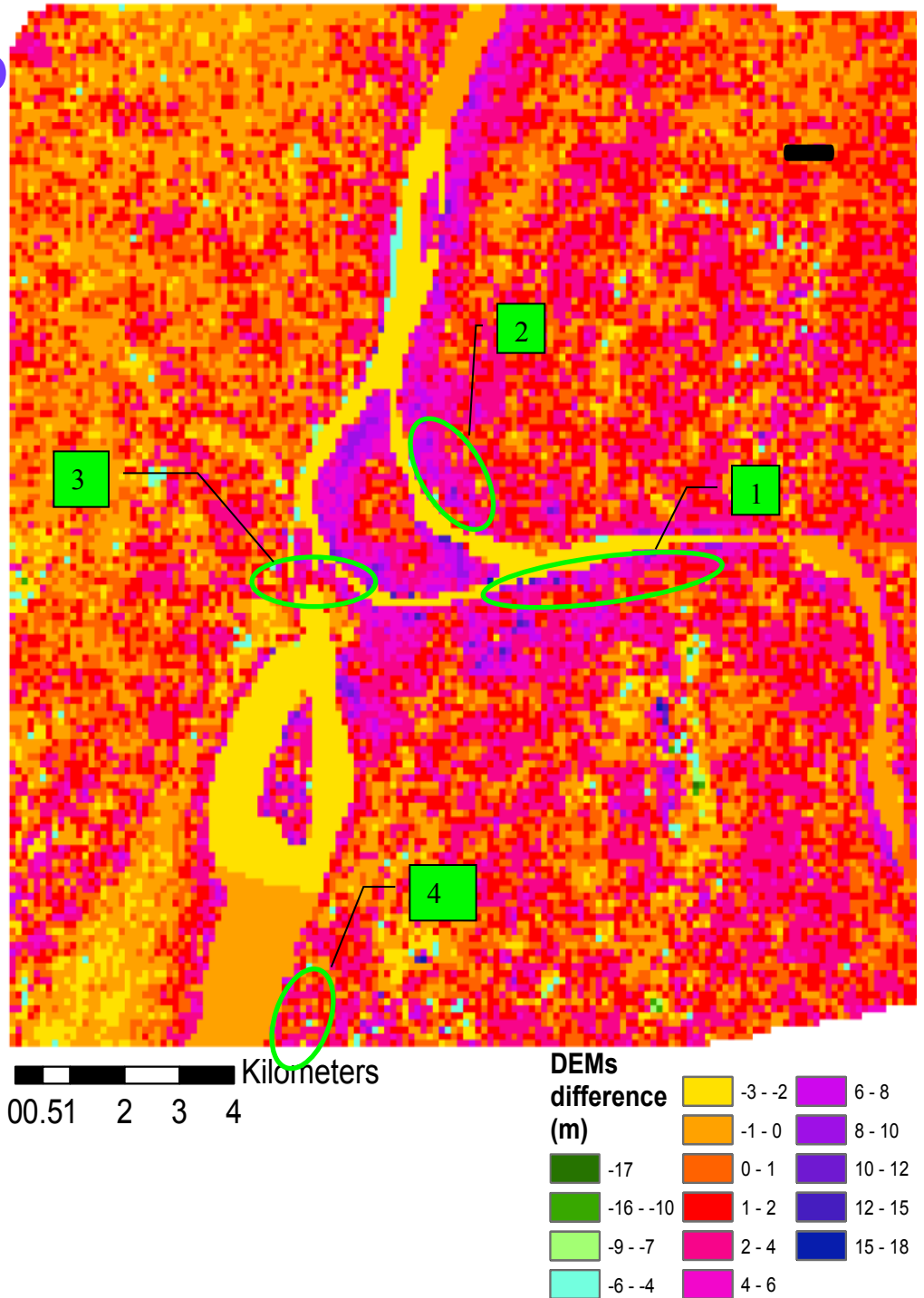
- **Downstream boundary condition:**

1. MainNile (W.L).

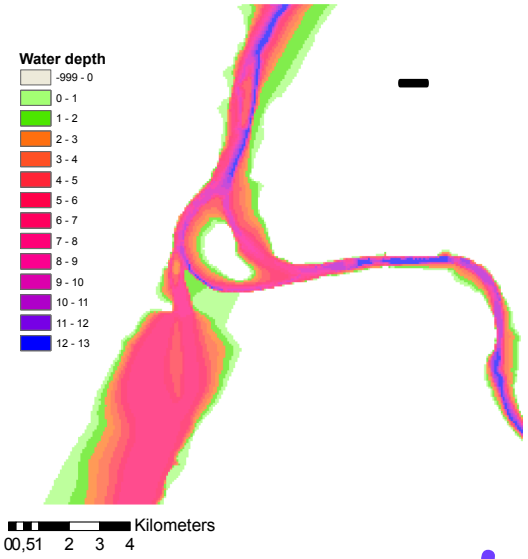
- History points.

Result o

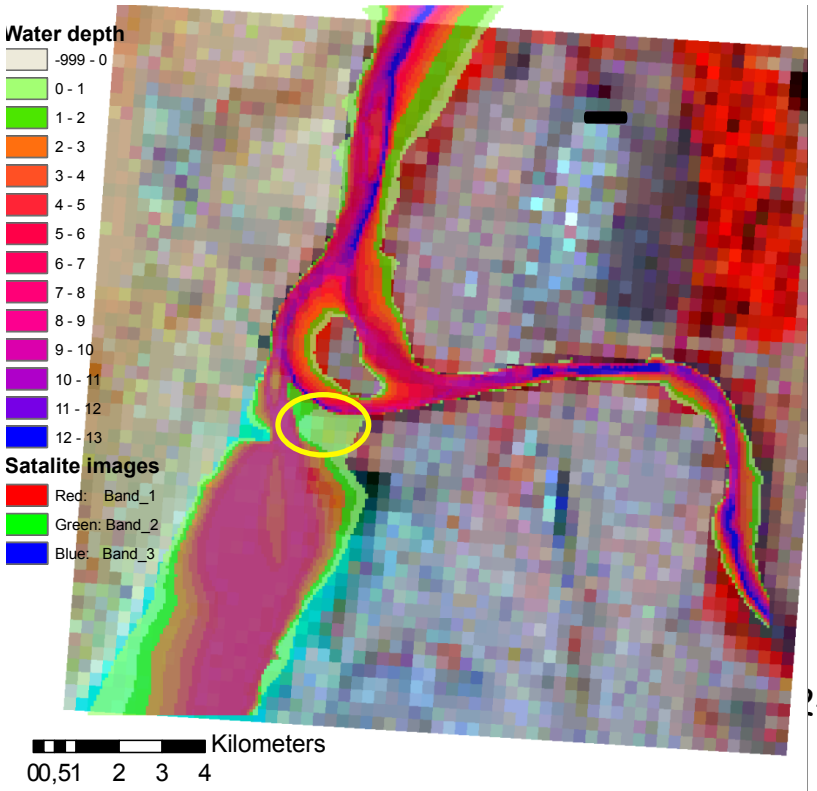
Comparison between the topographical elevation map and SRTM elevation map



Overlay the model result with the remote sensing image



- Result of the model at 18 of August 2000.
- Result of RS at 18 of August 2000 (NASA).
- Overly the result With RS.



Expected climate change scenarios

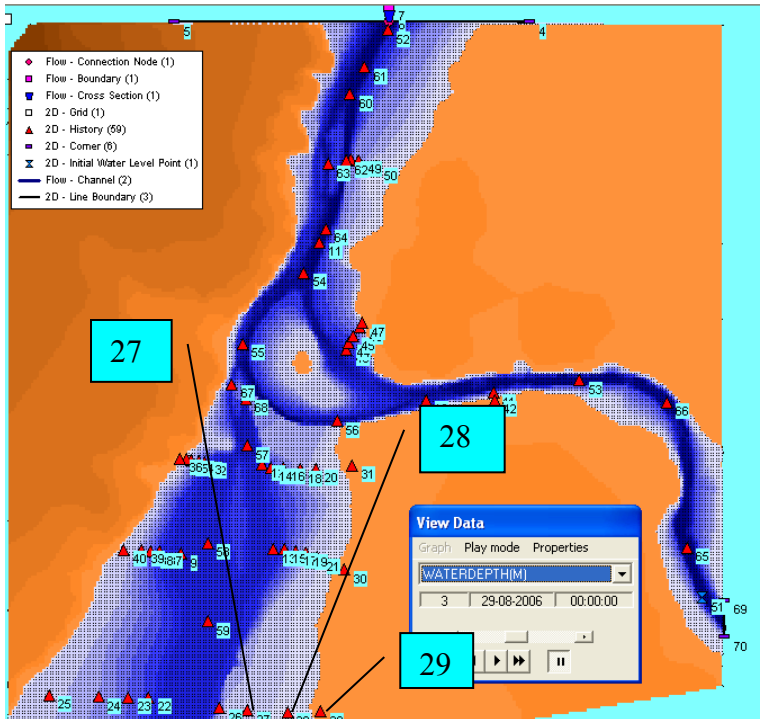
- Africa is the most vulnerable region to climate change.
- Boko et al., (2007) expected Rainfall to increase in some parts of East Africa.
- Strzepek et al., (1995) expect for future Nile flow:

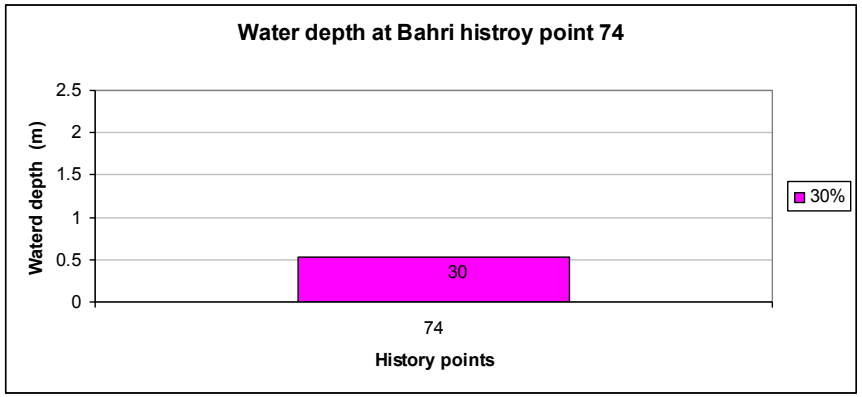
  GISS—a 30% increase. UKMO—a 12% decrease. GFDL—a 78% decrease.

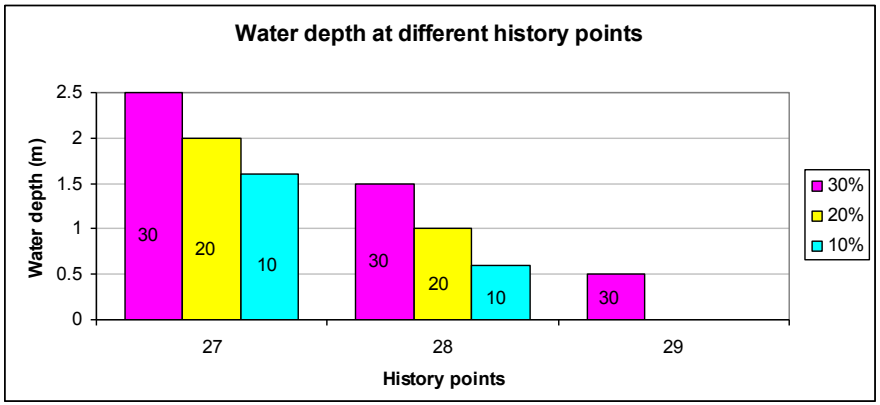
- Conway and Hulme, (1996) expected 2to 5 % increase in rainfall.
- Young, (2004) expected 6% of the Nile increase at Aswan Dam .
- Kim, (2007) expexted 11% increase in the precipitation.
- Yimer, (2008) expected 15%.

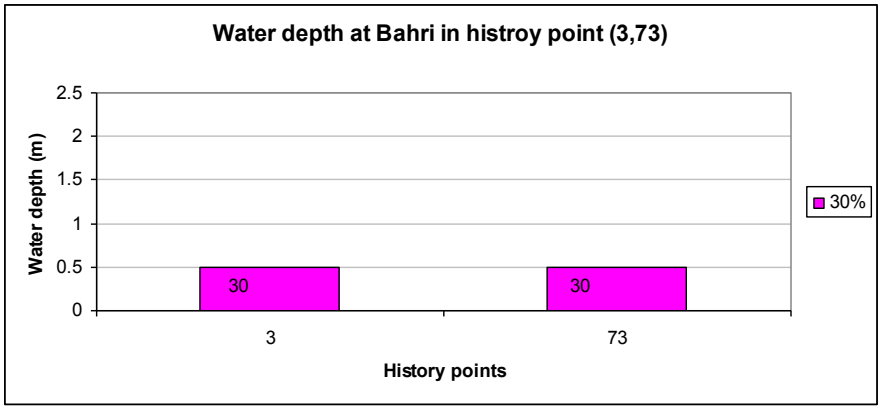
The majority of the models expected an increase in the Nile flow.

SOBEK result for flood extent and depth for 10% extra than29 of August 2006

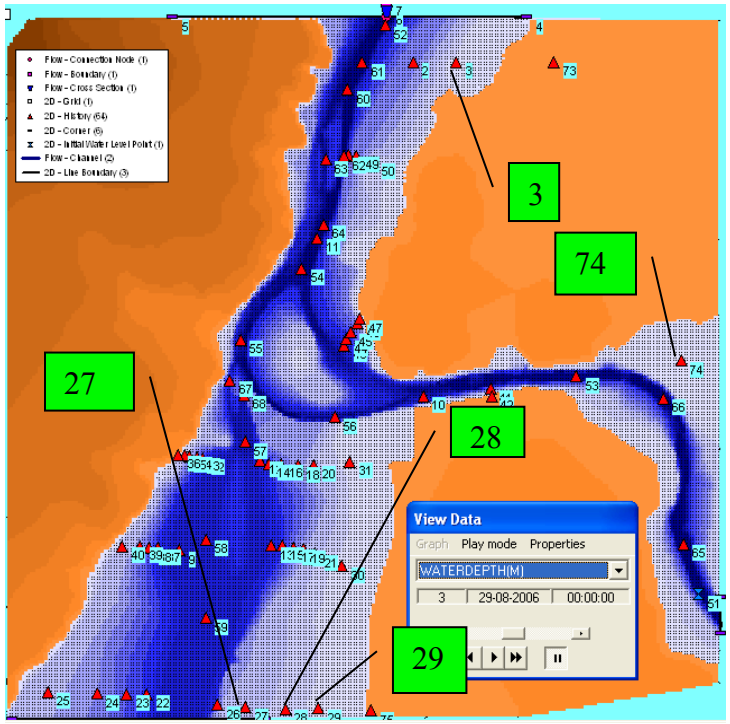


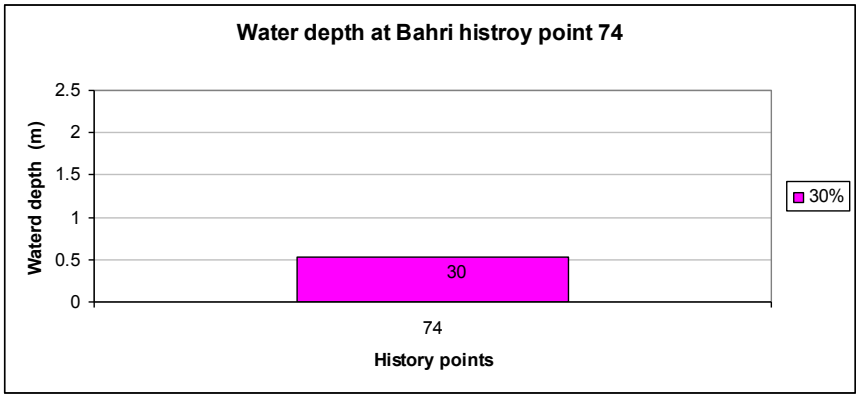


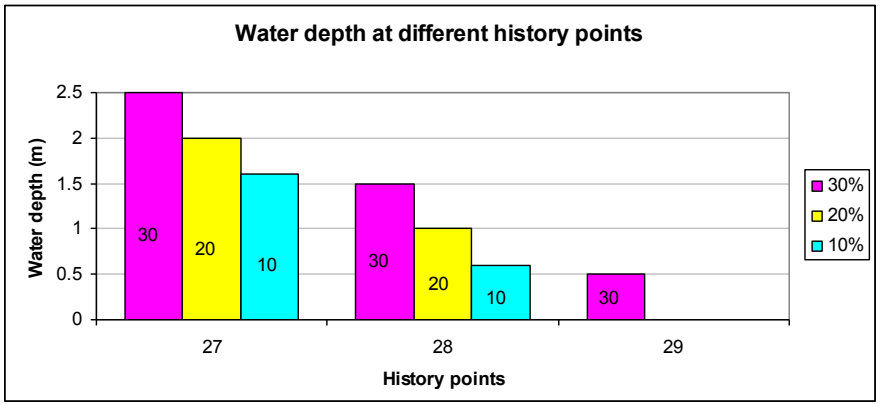


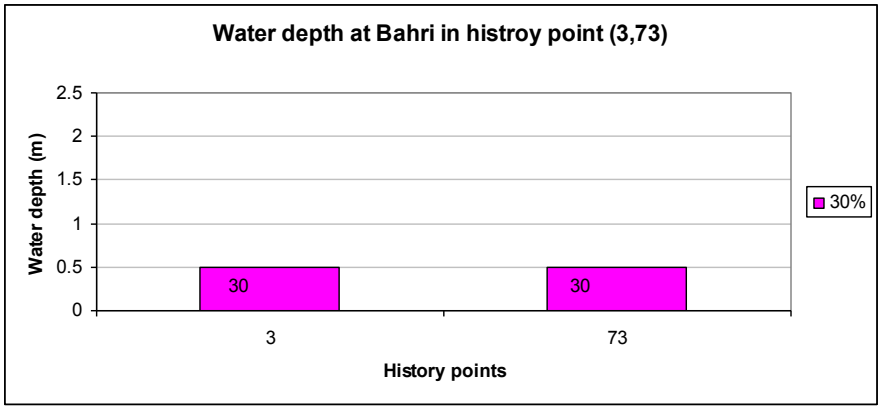


SOBEK result for flood extent and depth for 20% extra than29 of August 2006

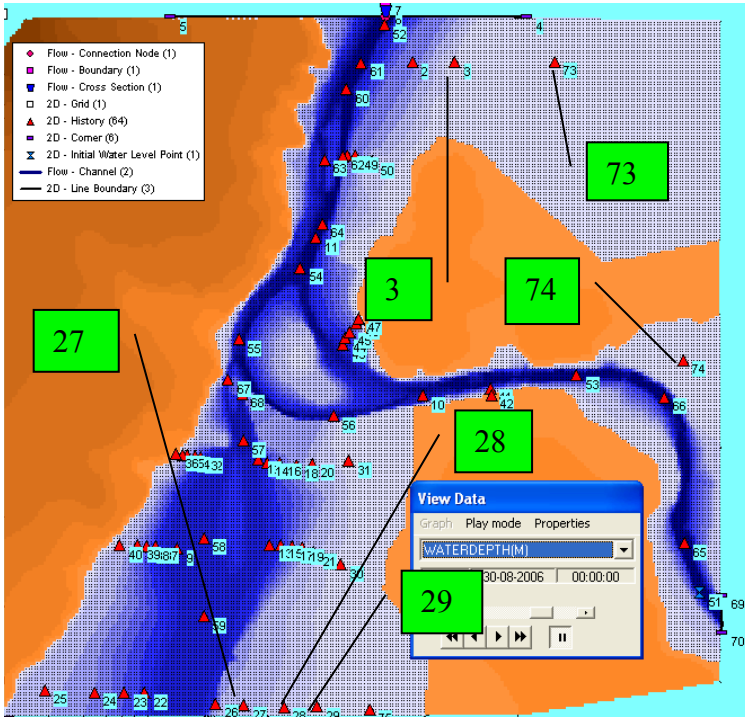


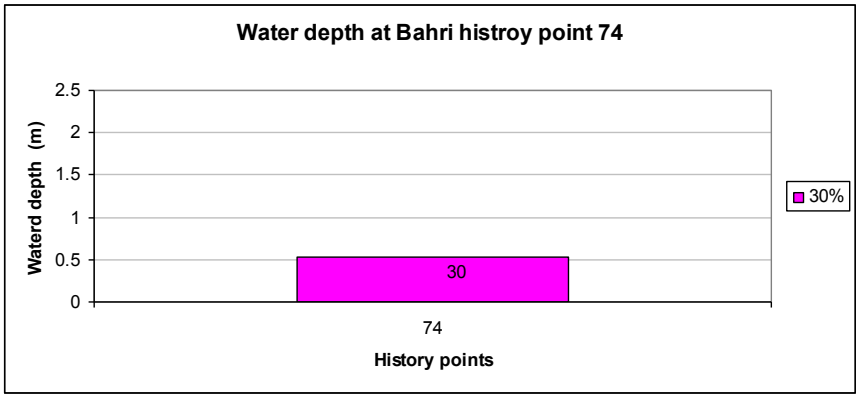


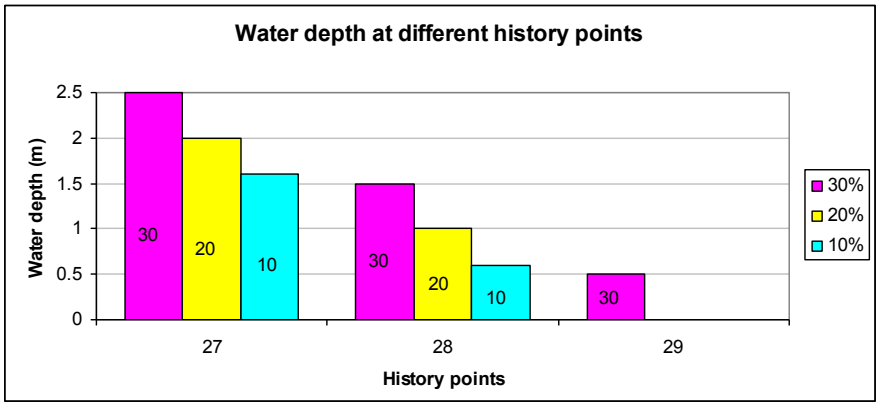


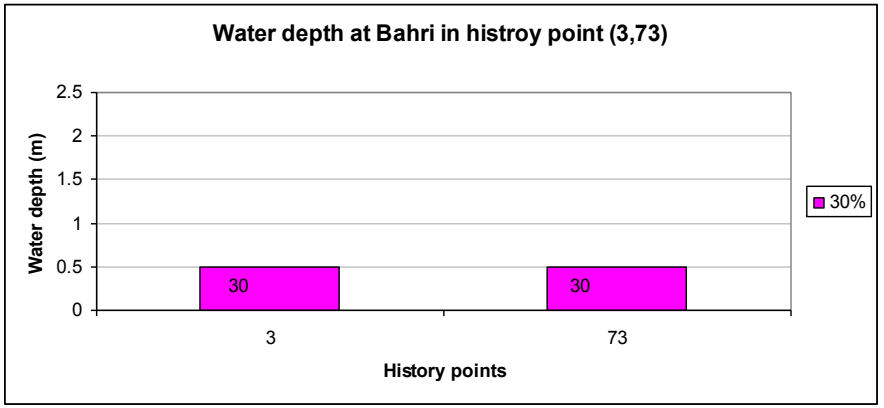


SOBEK result for flood extent and depth for 30% extra than29 of August 2006

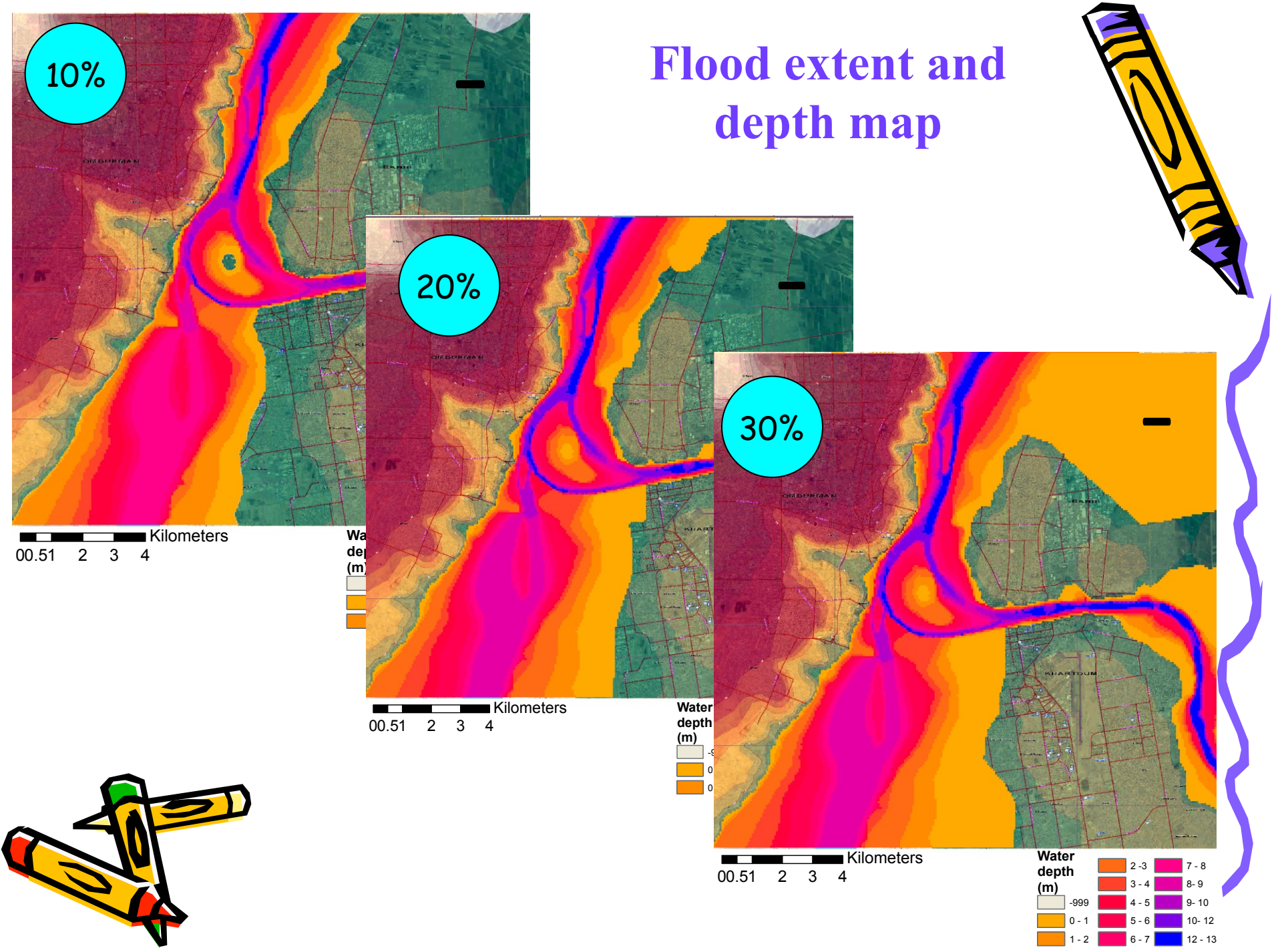




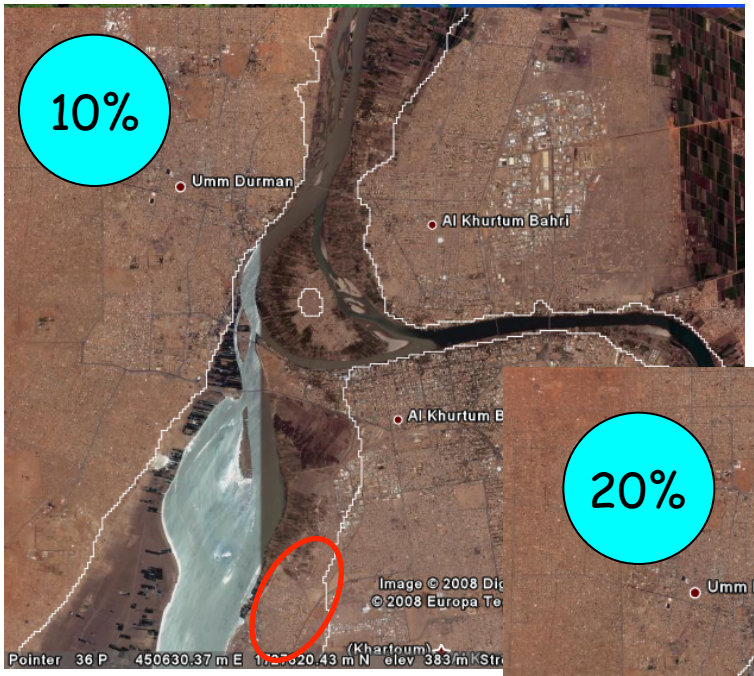


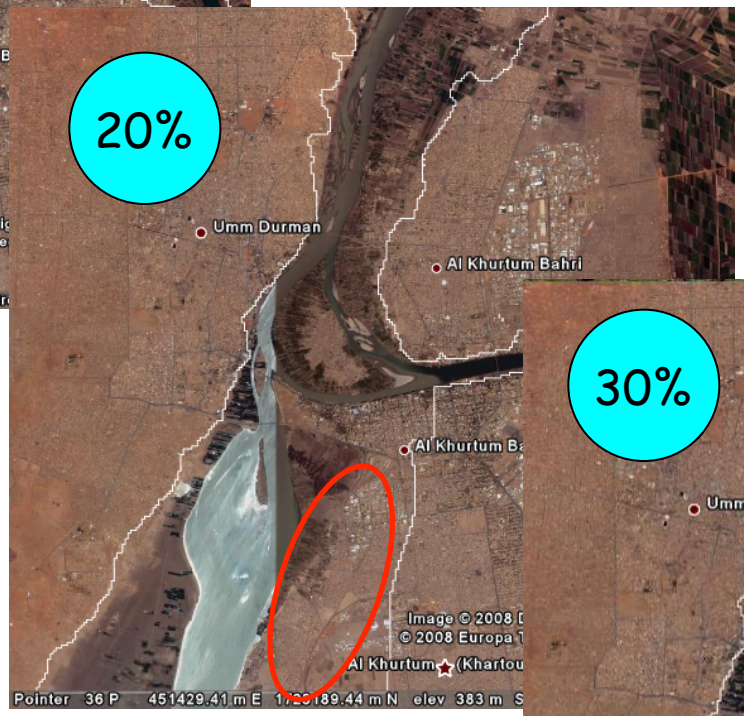


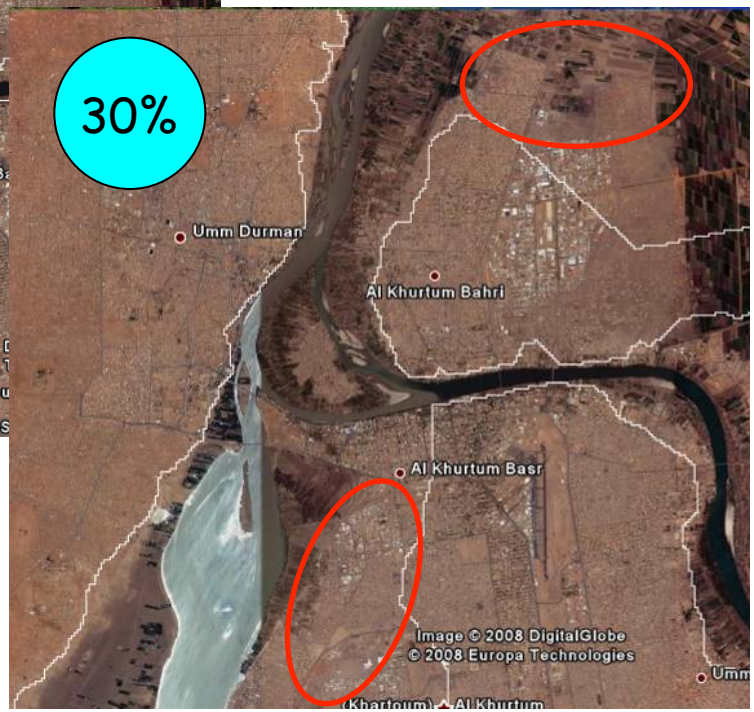
Flood extent and depth map



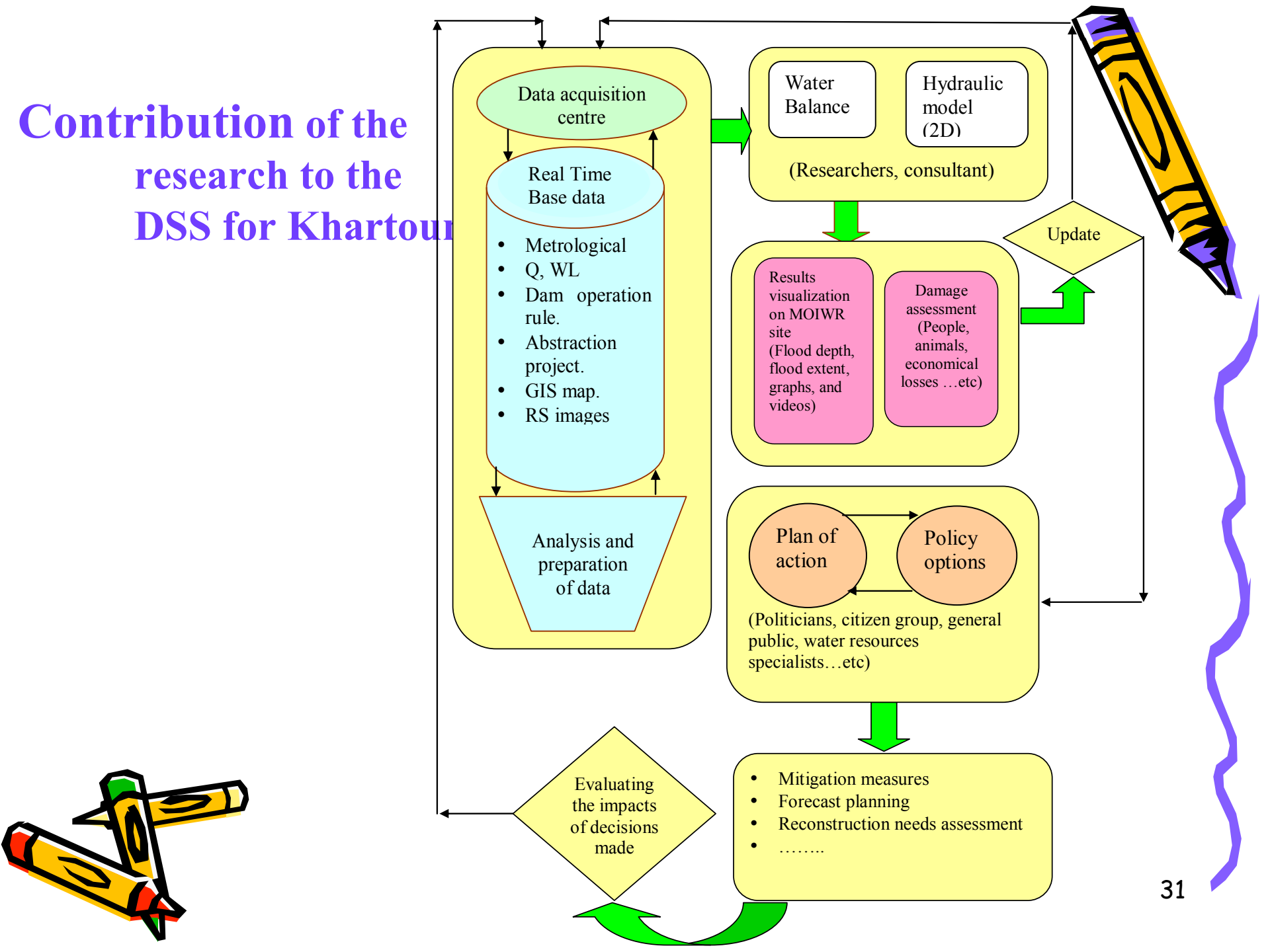
Flood extent in Google Earth







Contribution of the research to the DSS for Khartoum



Conclusion

- Sudan suffers on average every 2 to 3 years from flood.
- Water balance for the reach Sinnar and Khartoum show good results.
- Water balance for the reach between Rosseries and Sinnar Dam gave good results.
- Flood occurs due to prolonged and high rainfall in the upper catchment Ethiopia. Sometimes, the situation is worse when it is accompanied by high local rainfall.
- The flood extent from SOBEK compared with the remote sensing images were almost same.

Conclusions' cont

- Omdurman was almost not affected by the flood due to climate change, Bahri was more affected and Khartoum was highly affected.
- The flood extent map will provide the decision makers with flood risk zones, and will help in spatial planning.
- **The most important factors which govern building a good 2D model is, a good digital elevation map and the boundary conditions for the model.**
- **The differences between the SRTM digital elevation data and the elevation topographical map were large (35 meters).**
- **SRTM free source for DEM map is not recommended to be used for the extension of the flood in Khartoum.**

Recommendations

- Refine and improve the water balance.
- For the preparation of the topographical map the streets were not included in the map , and the topographical map should be extended.
- Culverts and pipes under the street also should be included
- Optimization to Jabal Awliya dam.
- A 1D/ 2D model should be made to improve the boundary condition locations.
- The temporary barriers by the local people should be included in the model.
- Expansion of the 1D/ 2D model to the upstream to include other cities.

Recommendations

- Damage functions for the expected inundated areas should be Calculated .
- A cost benefit analysis should be made for building a dike along the river bank of Khartoum in the White Nile.
- A rainfall runoff model for the upper catchment should be made. Moreover, Satellite-based rainfall estimate could be used as an input.
- A code which will connect these entire model together for real time forecasting.
- Upgrade the existing FEWS with the lead time and flood extent.

Thank you