Impact of Climate Change on the Ecohydrology of the Nile River Basin

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Presentation Outline

- Introduction
- Upstream Catchment degradation
- Climate Change in the Nile
- Modeling tools
- Impact of climate change
- Adaptation strategies

Major threats in the Nile Basin

Deforestation, Soil erosion - land degradation
Climate Change



Impact of soil erosion

- Land and water degradation are the major issues in the Upper Nile due to deforestation and soil erosion.
- Poor land use practices and improper management systems have played a significant role in causing high soil erosion rates, sediment transport and loss of agricultural nutrients.
- Studies indicated that Ethiopia loses about 1.3 billion metric tons of fertile soil every year and the degradation of land through soil erosion is increasing at a high rate, Hurni (1989)

River flow with high sediment concentration







Lake Adele

Lake Alemaya

Degradation in water bodies due to hydrological and environmental changes



Emboch

- the top 250 lake regions of Global Importance for Biodiversity
- the aquatic biodiversity at extreme risk due to invasion of Emboch – Aquatic weed (water hyacinth)





Modeling Tools

- Soil water Assessment Tool SWAT
- Generalized Environmental Modeling System for Surface waters (GEMSS)
- GIS based Multi criteria Evaluation





SWAT (Soil water Assessment Tool)

SWAT is a river basin scale developed to predict the impact of land management practices on water, sediment and agricultural chemical yields

The SWAT system (ArcSWAT), embedded within geographic information system (GIS), can integrate various spatial environmental data

GEMSS - Generalized Environmental Modeling System for Surface waters

- GEMSS is an integrated system of 3-D hydrodynamic and transport modules embedded in GIS
- The hydrodynamic and transport relationships used in GEMSS are developed from
 - the horizontal momentum balance,
 - continuity,
 - constituent transport and
 - the equation of state.



MCE-GIS tool for Decision support system

- Multi-Criteria Evaluation (MCE) is a method for decision support
 - number of different criteria are combined to meet one or several objectives.
- The decision was made after combination of four criteria (factor maps): Slope, Landcover, Soil types and River





MODEL INPUT DATA

GIS input files needed:

- the digital elevation model (DEM),
- land cover,
- soil layers
- > DEM
 - delineate boundaries, stream network
 - calculate average slopes
- Land use, Soil and Slope layers
 - to create and define Hydrological Response Units (HRU's).

MODEL INPUT CONT.

SOIL PHYSICAL PROPERTIES

- Number of layers in the soil
- Soil hydrologic group (A, B, C, D)
- Maximum rooting depth of soil profile
- Fexture of soil layer
- Depth from soil surface to bottom of layer
- Moist bulk density
- > Available water capacity of the soil layer
- Saturated hydraulic conductivity
- > Organic carbon content
- Clay content, Silt content, Sand content







MODEL INPUT DATA

Hydrological Data

- River Discharge and
- Suspended sediment load

Land Management

 data for management practices such as planting, harvest, tillage operations, and pesticide and fertilizer application.





Time series of measured and simulated flow, Gilgel Abay







Sediment Yield Modeling



Comparison between measured and simulated monthly sediment yield

- The annual average simulated sediment yield was 28.7
 - Calibration period: NSE=0.81, PBIAS=28 %, RSR=0.23 & R²=0.85
- Validation period: NSE=0.79, PBIAS=30 %, RSR=0.29 & R²=0.80

Erosion vulnerable areas in Lake Tana Basin, Ethiopia



Climate Change

30 August 2010, Gran Melia, Puerto Rico, photo by Shimelis S

CLIMATE CHANGE

Climate change is a significant change in the statistical distribution of weather patterns over periods. eg. weather conditions or the distribution of extreme events.



Climate Change

By 2040 the share of people in the Nile region facing water scarcity could reach 35%. That's more than 80 million people, *Coffel and Mankin 2020*

250 million people rely on the Nile for water that may not exist by 2080, Zoë Schlanger 2019

EFFECT OF CLIMATE CHANGE

 A major effect of climate change is alterations in hydrologic cycles and changes in water availability.



Increased evaporation & changes in rainfall, has the potential to affect runoff, floods and droughts

Assessment of impact of climate change

- Assessing the impact of climate change involves
 - Projections of climatic variables (e.g. precipitation, temperature) at a global scale.
 - Downscaling of global-scale climatic variables to local-scale hydrologic variables





PROJECTED CHANGES





Projected seasonal changes in rainfall



Decreasing rainfall trend

Projected seasonal changes temperature



Variation among GCM outputs for different SRES -Precipitation/ Rainfall



Impact of Climate Change on Water Resources



Water Resources and Climate Change Blue Nile – Lake Tana

ETHIOPIA - Lake Tana Basin

- Lake Tana basin comprises an area of 15096 km²
- The lake is a natural type
 - Average area = 3300 km^2
 - Maximum depth = 14 m.
 - Inflow Rivers are GilgelAbay, Ribb, Gumera, Megech

Impact of Climate Change on Surface and Ground Water 2046-2065





Hydrodynamics of Lake Tana - using Combined SWAT and GEMSS model







Temperature contours and the velocity vectors, <u>section S5</u>, January 2, 2006), legend color in \degree C.



Adaptation strategies - Measures

- Appropriate catchment treatment strategies should be implemented
 - Watershed management methods like afforestation and water conservation are recommended to reduce the impact on the Blue Nile basin.
- create an equitable water allocation scheme upstream and downstream countries.
 - "historical rights" –Egypt's long-held claims need to be revised so that the needs of upstream countries like South Sudan and Ethiopia, which require water to build their economies, should be highly considered
 - Water may be often pointed to as a source of conflict, but it can also be a means to cooperation, getting nations to the negotiating table.
- Any intervention and planning strategies should highly consider the short and long-term climate variability and change

Thank You!