Location	Tana and Beles Basin, Ethiopia
Contractor	WorldBank, Nile Coordination Unit
Period	2001

Background of the project

The Blue Nile provides the greater part (about 60%) of the flow of the main Nile. Under the Nile Basin Initiative (NBI), the Eastern Nile Committee of Ministers have agreed to initiate a number of projects. One of the fast track projects is the hydrological analysis and water resources development of the Tana-Beles basin. Within the Tana-Beles basin, there is ample opportunity to maximize growth by optimizing land and water resources development. Before any measures can be initiated, the current knowledge base on water resources has to be improved. Several studies have been conducted before, and the hydrological results differ. Part of the reason is that field data sets are difficult to get access to, and that the hydro-meteorological observation network is sparse anyway. One of the debated issues is the evaporation loss from the vast Lake Tana.

Figure 1: An overview of the Blue Nile basin outlined in white, the Beles basin outlined in green and the Tana-basin outlined in yellow.

This project is a brief explorative study to estimate the dynamics of evaporation and rainfall in the Tana-Beles basin in the year 2001 by means of advanced remote sensing technologies. Also the water balance for the lake, Tana-basin and Beles basin for 2001 has been calculated. The year 2001 has been chosen because it represents an average year.

Study approach

Data from the MODerate resolution Imaging Spectroradiometer (MODIS) satellite has been used to estimate the land surface energy balance at basin scale with use of SEBAL. The large MODIS swath width of 2330 km and its daily repetitive image acquisition, is suitable to cover large river basins such as the Tana-Beles Basin. An overview of the Tana-Beles basin is shown in Figure 1.

Results

The map with the monthly ET for the Beles basin in 2001 is presented in Fig. 2. Another map with the monthly rainfall for the Beles basin in 2001 is presented in Fig. 3

The analytical analysis of the water resources in Tana-Beles basin has been executed with limited field data, and it provides a systematic diagnosis of a vast area that is expressed into a number of deterministic parameters such as (i) terrain elevation, (ii) land use, (iii) rainfall, (iv) evaporation and (v) soil moisture. The runoff is estimated as the difference between rainfall and evaporation, and can be considered as a 6th parameter to describe the basin hydrological behavior quantitatively. The results are found to be consistent with values reported from previous studies.

Evaporation dynamics

Evaporation dynamics are similar in the Beles and Tana basin. In spring there is a low evaporation rate due to soil water constraints. In the Summer, when the rainy season starts, evaporation rate increases, reaching it's peak in October just after the rainy season when soils are all still wet, and solar radiation is stronger than in August and September due to reduced cloud cover. The evaporation gradually decreases after October, following limiting soil moisture conditions. The annual accumulated evaporation ranges from 250 mm/year for sparse upland vegetation to 1500 mm/year for forests in the southern part of the Beles Basin. The forest evaporation is more than 1000 mm/yr due to the deep roots that tap sufficient water resources to overcome the dry period. Lake Tana itself has an annual evaporation of 1588 mm/year. Lake Finch has higher surface and air temperatures and evaporates at a rate of 2345 mm/yr in 2001.

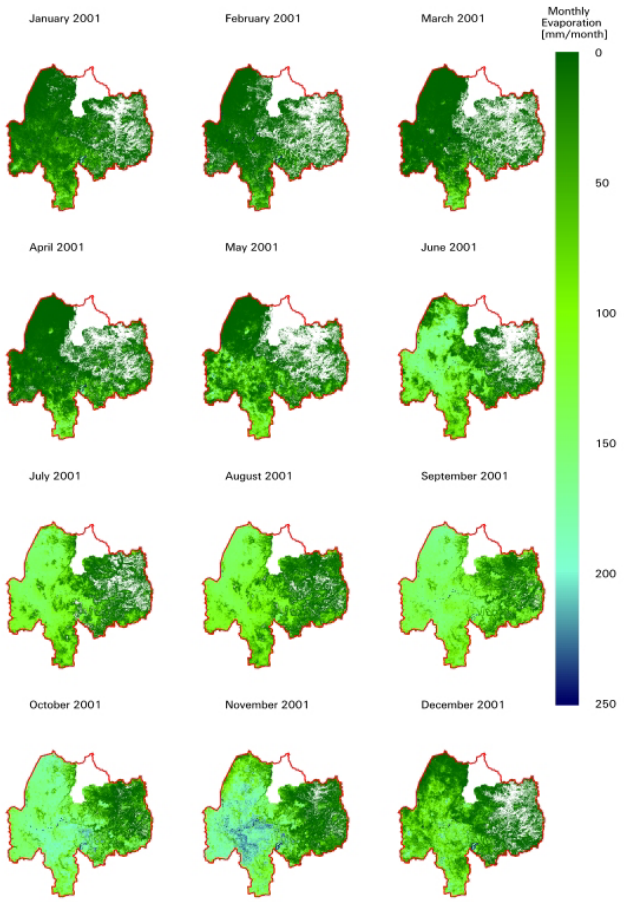

Figure 2: Evaporation Dynamics of Beles Basin, 2001

Rainfall dynamics

The majority of the rainfall pours down from May to September, with the largest amount falling in July. Due to the stronger developed Inter-Tropical Convergence Zone (ITCZ) in the Beles Basin 91149 mm/yr), there is more rainfall than in the Tana Basin (1020 mm/yr).

The steep slopes in the western part of the Beles Basin are responsible for the fast surface runoff into the Abbay, with quickly swelling discharges when the river coarse transverses from Lake Tana to Roseires Reservoir. The outflow of the Beles Basin can probably only be assessed from remote sensing technologies because there are several parallel ungauged rivers and streams that drain into the Ethiopian lowlands and Sudan.

Soil Moisture dynamics

The soil moisture follows closely the rainfall patterns. In spring and winter the soil moisture content is quite low. Only during the rainy season the soil moisture content increases, most notably in the western part of the Beles basin.

Water Balance

The water balance is presented in the text box below. The outflow from the Beles basin of 48,658 MCM/yr through the Blue Nile at El-Deim relates to a part of the basin area. An unaccounted amount of 47,726 MCM/yr flows out via other rivers (Dinder, Rahad, Galegu and Dibaba) parallel to the Abbay into the lowlands of Sudan.

Conclusions

This remote sensing study describes an analytical analysis of the hydrology of two large catchments in the highlands of Ethiopia that have limited hydrological field data. The analysis has been carried out for one year only, and is merely meant to appraise the new opportunities that remote sensing technology offer in the quantitative description of hydrological flows. The remote sensing potential can be improved if during subsequent studies longer time series of satellite measurements are to be included.

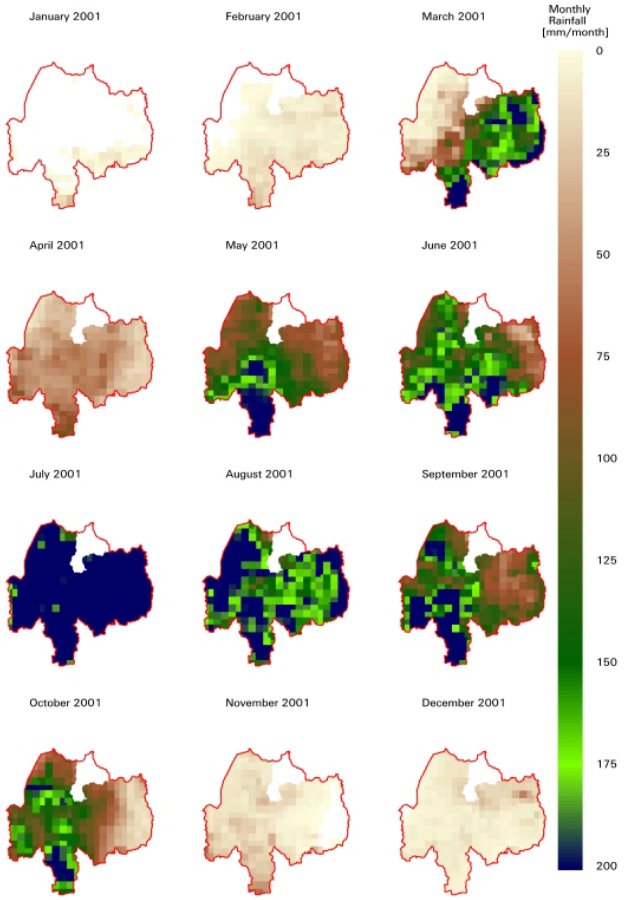

Figure 3: Rainfall Dynamics of Beles Basin, 2001

Water Balance (2001)

Lake Tana (area 316,631 ha)		
Precipitation Lake	1541 mm/yr	4,879 MCM/yr
Evaporation Lake	1588 mm/yr	4,735 MCM/yr
Inflow Lake	1616 mm/yr	5,118 MCM/yr
Change in Lake level	70 mm/yr	221 MCM/yr
Percolation losses Lake	0 mm/yr	0 MCM/yr
Outflow Lake	1499 mm/yr	5,041 MCM/yr
Tana Basin (area 1,429,344 ha)		
Precipitation	1020 mm/yr	14,881 MCM/yr
Evaporation	672 mm/yr	9,611 MCM/yr
Change in storage	16 mm/yr	229 MCM/yr
Outflow Tana Basin	353 mm/yr	5,041 MCM/yr
Beles Basin (area 18,526,594 ha)		
Precipitation	1149 mm/yr	212,775 MCM/yr
Evaporation	655 mm/yr	121,432 MCM/yr
Inflow Blue Nile	27 mm/yr	5,041 MCM/yr
Outflow Blue Nile	263 mm/yr	48,658 MCM/yr
Outflow other rivers	258 mm/yr	47,726 MCM/yr

WaterWatch
Generaal Foulkesweg 28
6703 BS Wageningen
The Netherlands

Tel: +31 (0)317 423 401
Fax: +31 (0)344 693 827
Web: www.WaterWatch.nl
E-mail: info@WaterWatch.nl