Abaya-Chamo Lakes Physical and Water Resources Characteristics, including Scenarios and Impacts

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Introduction

Prior to 2000, until the GTZ supported research project constituting a number of sponsored Ph.D. studies and research program in Arba Minch University that have produced results, little information was available regarding the water resources systems of Abaya and Chamo Lakes which are found in Southern Rift Valley Region of Ethiopia. Some of the key challenges of the basin are:

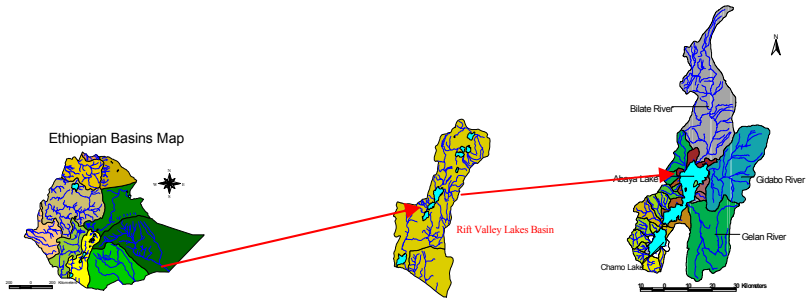
- Increased population and insufficient developed resources to support the rapidly increasing population
- Inadequate agricultural food production
- Limited use of water for irrigation, arbitrary use of potential & poor management practice in the existing irrigation schemes
- Overuse of forest as firewood while hydropower and other alternative energy sources are not developed
- Severe erosion, loss of soil, loss of land due to combined effects of deforestation, overgrazing and poor-tillage
- Degradation of bed and bank, transportation in rivers and hence deposition of sediment in the lakes
- Inadequate clean water supply, improper sanitation and as a result poor health status of inhabitants of the region
- Flooding of areas surrounding the rivers, loss of possessions and damage of infrastructure
- Potentially receding lake volume and size
- Production of toxic substances in the lake such as blooming of algae
- Literally non-existent coordinated water resources research efforts in tackling the problems of the basin

Against this background and investigation of various characteristics of the lakes systems, this paper discusses the following issues, based on the Ph.D. research results of the author:

- GIS based watershed characterization of the watersheds of the Abaya and Chamo lakes
- Information on understanding the physical and morphological characteristics of the two lakes
- Hydrological information and generation of time series data for gauged and ungauged watersheds based on modelling
- Water balance model of the two lakes, development of scenarios and evaluation of impacts

GIS based watershed characterizations

The study basin for which the above mentioned model was developed and tested is found in southern part of Ethiopia. Figure 1 shows the location on Ethiopian Map and the particular major basin which is the rift valley basin in which the study area drainage system is found. The study drainage system, although a sub-basin of rift valley lakes basin, is considered as Abaya-Chamo Basin (ACB) and constitutes 3 medium rivers and a number of small and ephemeral rivers. In addition it constitutes 2 Lakes which are interconnected through surface overflow. The rivers are draining in to the two Lakes from surrounding relatively large slopes of rift valley escarpments.



Abaya-Chamo Basin

Figure 1: Abaya-Chamo Basin Location on Ethiopian & Rift Valley Drainage Map with Major Rivers

As a result of the GIS and Digital terrain Model based analysis using Arc View, Auto-CAD and WMS softwares, the total area of ACB including the lakes and their islands is found to be 18,599.8Km^2. Summaries are provided in **Error! Reference source not found.**Table 1, for further details see Awulachew (2001).

No.	Sub-Basin	Total Area in Km^2
1	Abaya Drainage Area Excluding Lake Area	15219.62
2	Lake Area including Islands	1108.9
3	Chamo Drainage Area Excluding Lake Area and Abaya Contribution	1942.65
4	Chamo Lake	328.63
5	**Total**	**18599.8**

Sample output of the drainage information system is provided for Bilate Lake sub-basin (Northern part of the ACB), which is showing sub-basins definitions based on sub-drainage characterizations

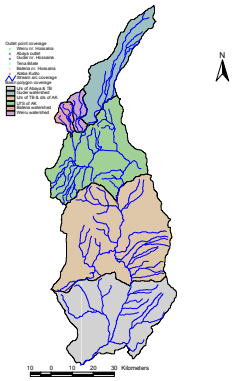


Figure 2: Bilate Sub-basin

Physical and Morphological Characteristics of the Two Lakes

A six months bathymetry survey was undertaken on the two Lakes and the resulting morphomoteric characteristics derived as a result. The background lake map has been digitised and surveyed data has been also developed as digital values. The digital values have been interpolated and grids of the elevation surface have been generated. From the digital values elevation area and elevation volume curves (capacity curves) of the two Lakes, which can describe the water resources capacity of the lakes body, have been developed. This component has enabled understanding of the Lakes in terms of size, characteristics, capacity, vulnerability due to various factors, etc. Figure 3 provides the derived contour maps of the two lakes.

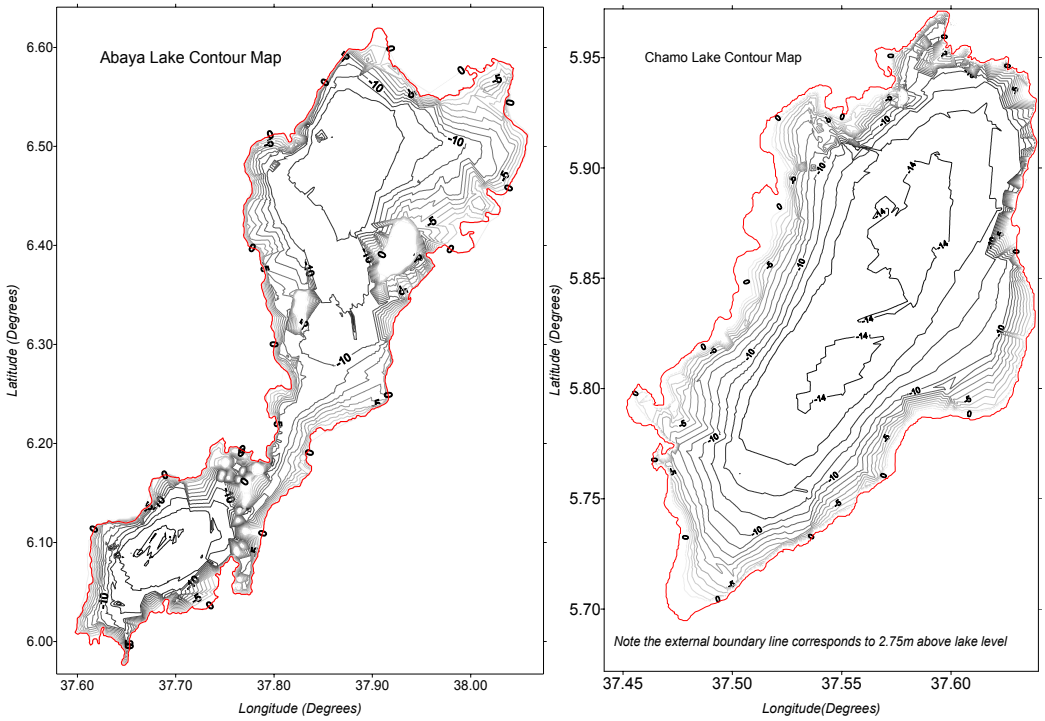


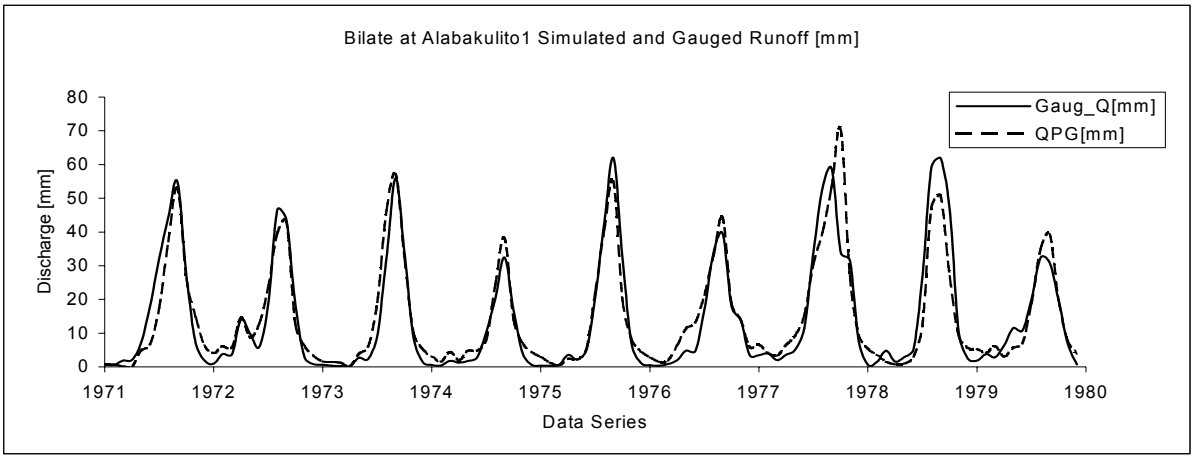
Figure 3a) Abaya Lake Contour b) Chamo lake contour

Hydrological Data Analysis and Modelling

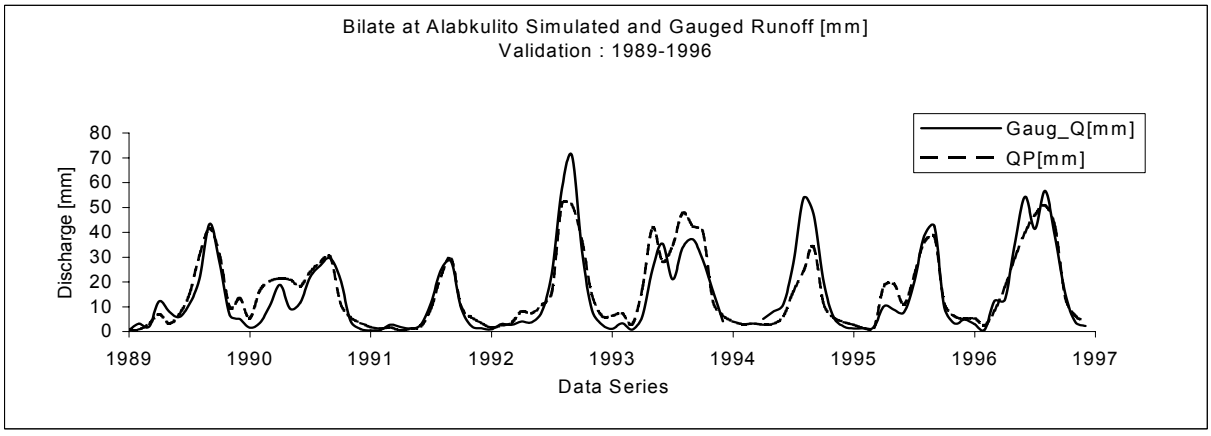
A monthly water balance model, known as MOWBAL, which can be used to generate runoff based on few parameters, is developed. The model in this study uses variables of rainfall and evaporation as an input and runoff as an output on a monthly basis. In the model, 2 optimized calibration parameters and 6 conceptual functional parameters are employed. The model is particularly useful for simulating runoff in cases of limited hydro-meteorological and physical data, and where climatic conditions lead to low or large rainfall variations, like in temperate or semi-arid regions respectively. The model is used to simulate the runoff of 8 sub-catchments of the Abaya and Chamo Lakes drainage basins of Ethiopia. The results of both calibration and validation show the model performs acceptably well and can be used to generate runoff for similar catchments like the study area considered. The developed model is successfully applied to generate runoff

for the ungauged areas to further study the water balance of these remotely situated natural lake systems where data is limited.

Data of the ACB for gauged sites were used to calibrate and validate results. Figures 4 shows such result for Alaba-Kulito station and shows good performance.



a)



b)

Figure 4: Alabkulito Gauged and simulated runoff plot in the a) calibration b) validation periods

The development of such model has enabled, not only helped to extend hydrological data for gauged basins, but also helped estimation of such data for ungaguged data and development of water balance model of the Lakes

Water balance model of the two lakes, scenarios and impacts

In this component, modelling of the water balance components and there by impact of water use, sediment transport and deposition are highlighted. In order to be able to develop the water balance model, the various outputs discussed in the previous section and not reported in this paper such as watersheds of the lakes system, morphometry of the

Lakes, rainfall-runoff model. These information systems have been integrated to model the water balance of the Lakes which simulates the water level.
The structure of the model that was used for this study is shown in Figure 5.
The program for water balance named, LAKEBAL, has been developed and the modelling process constitutes three stages:

- Pre-processing of input data and selection of model parameters
- Simulation and computation of water balance components by executing the simulation program
- Post processing of output from simulation result

The Figure shows the sources of various components of the input data elements and their interaction in the modelling process.

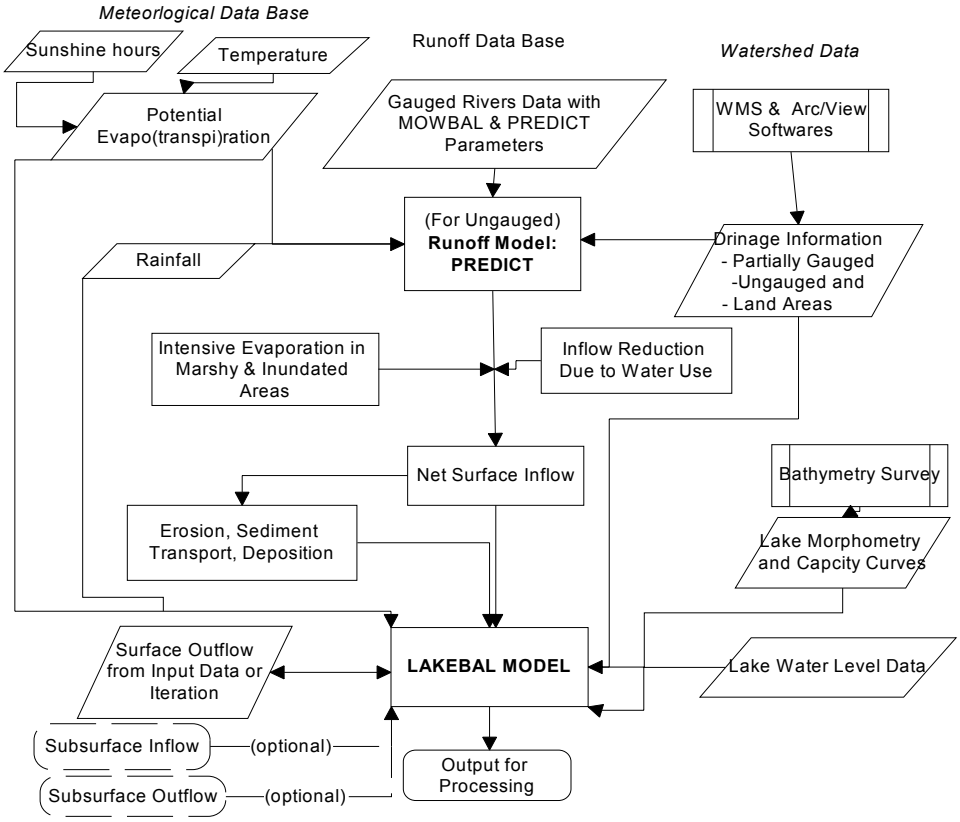


Figure 5: Data Input Elements and Interaction of Various Elements in LAKEBAL model

The results generated by this model are found in Awualchew (2001). Based on the simulations result and computation of life expectancies, it is found that sediment inflow and deposition are the most detrimental factors for the two Lakes, not the development impacts.

Keywords: Bathymetry survey, capacity curves, GIS, life expectancy, MOWBAL rainfall-runoff model, LAKEBAL water balance model, scenarios, impacts.