THE IMPACT OF LAND COVER AND LAND USE ON HYDROLOGICAL RESPONSE IN THE OLIFANTS CATCHMENT[1]

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Abstract

The promulgation of integrated water resources management dictated by the South African Water Act coupled with increasing international pressure for adopting IWRM principles has promoted renewed interest and need for detailed hydrological modelling. This project therefore seeks to provide a high resolution hydrologic model for selected quaternary catchments of the Olifants Catchment to aid the water sector in optimally using and planning water related projects, particularly the sectors that require models of a smaller time scale than has been previously provided. This shall encompass assessing and modelling runoff generation; investigating the effects of land cover and land use and investigating upstream-downstream interactions of the selected catchments. The results of the model shall be compared with results from the monthly time-step models currently in use and a linkage to such models shall also be provided.

Introduction

The advent of civilisation brought with it the need to 'tame' the environment through various human activities which altered the environment in various forms. Most of these anthropogenic changes have a profound effect on the water cycle and ultimately, on the availability of water and quality of water resources. Such effects are critical as water is crucial for human and environment sustenance and development. In the light of such development, there are now a number of issues that are becoming more pertinent in man's quest to improve his livelihood and environment. Such issues include environmental protection, sustainable development and the effects of climatic change. It is becoming more important to forecast the effect of land use changes, agricultural practises, afforestation and deforestation and related activities on water resources. This is taking place over and above the growing concerns of a global water crisis with about a third of the world's population living in water stressed environments.

The prevalent global water crisis has prompted a lot of activity in integrated water resources management. It is becoming increasingly important to know the amount of fresh water resources that are available and how these can be optimally and equitably allocated to the increasing population. As Southern African nations embrace water reforms, they are becoming more aware of the need to estimate the amount of available water and how this quantity and quality can be affected by any changes, both in space and time, in the natural environment and by anthropogenic activities.

South Africa has made tremendous progress in adopting integrated water resources management, including the underlying principles, and water is on the top agenda of the government. The Water Act of 1998 sets the policy framework on addressing water related issues. One mandate that is given the Minister of Water Affairs and Forestry is to establish national monitoring and information systems. The purpose of the systems is to facilitate the continued and co-ordinated monitoring of various aspects of water resources by collecting relevant information and data, through established procedures and mechanisms. A crucial part of the data that has to be collected and processed is hydrological information, with the output at high enough a resolution to be beneficially and easily put to use by the different water using sectors in the country.

With competition to meet the varying needs from the domestic, commercial, industrial and the agricultural sector and also the demand to meet the Reserve requirements it is clear that hydrological tools are necessary to help inform discussions about potential changes in water-resource policies and investment plans.

This project therefore seeks to provide hydrological tools for selected quaternary catchments of the Olifants, to aid the water using sector in optimally using and planning water related issues.

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Background

To facilitate management of water resources in South Africa the country has been divided into seven strategic planning areas or drainage regions, each of which has approximately uniform hydrometeorlogical characteristics (Basson *et al*., 1997 as quoted by McCartney, M P *et al*, 2004). The Olifants River Basin is one of the principal sub-catchments of the Limpopo River Basin and lies within the Northern Region strategic planning area of the country.

The Olifants Catchment is further subdivided into five water management regions, which are further subdivided into seven secondary catchments as shown in the figure below;

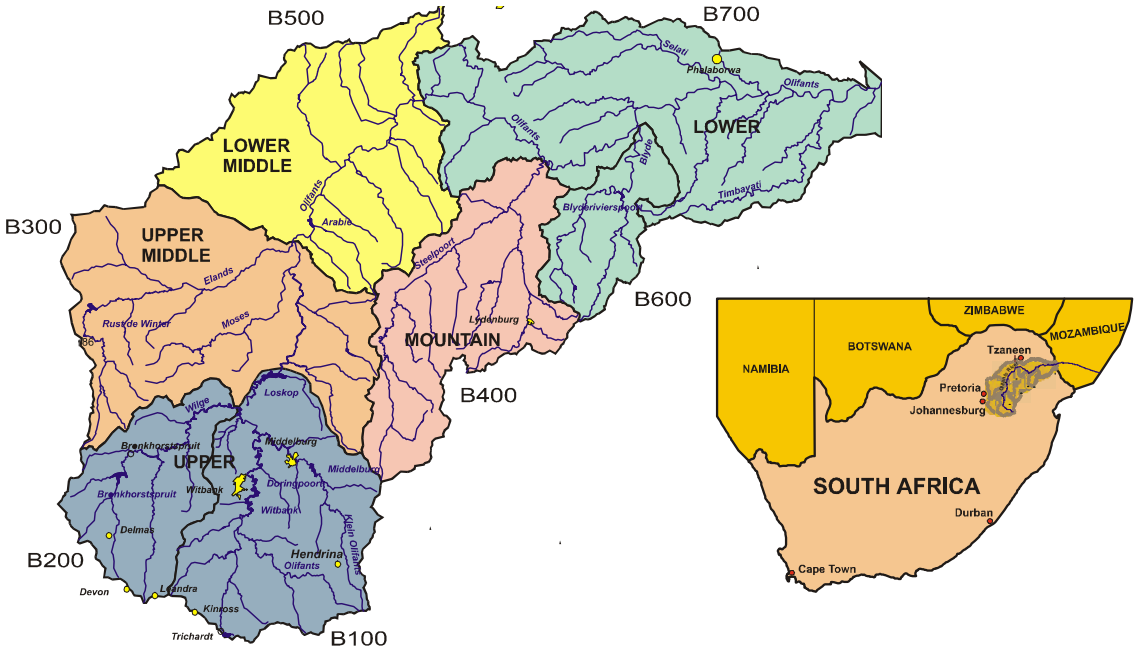

Figure 1: *Location of the Olifants River Water Management Area and the boundaries of the five water management regions.*

Table 1: ***Description of the Olifants basin.***

Catchment Area: 54,475 km^2
Location: between 2.5^o & 26.5^o South Latitude, between 28.5^o & 24.8^o East Longitude
Length of the Olifants: 770 km
Mean Annual rainfall: 630mm
Altitude: 300 – 2300m

Since 1990, there has been a lot of hydrological interest on the various river basins in South Africa. This saw the implementation of a Water Research Commission funded study known as the Surface **W**ater **R**esources of South Africa 19**90** (WR90). The study established quaternary catchments as the principal water management units, of which 117 are within the Olifants Catchment.

A second study which was a sequel to the WR90 study developed a Water Situation Assessment Model (WSAM) to evaluate the status of water resources in the country. A number of other related water resources studies on the catchment have been undertaken by different organisations and have given representative figures in terms of runoff generation and the yield of the catchment. What has been identified in some of these studies is that models that provide spatial and time step output at a high resolution will be needed to determine the available surface water resources, particularly in stressed area of Water Management Areas (DWAF, 2004).

General and specific objectives

General objective

The fundamental goal of this project is to provide a tool in the form of a hydrological model that will be used to determine the existing water resources within the catchment and thereby provide a basis for planners and decision makers upon which water allocation and management decisions can be made.

Specific objectives

Through the development of the process model, we will be able to;

- Assess and model runoff generation at a resolution that is relevant to all water users.
- Do an impact assessment and sensitivity analysis of the effect of climatic changes and anthropogenic activities, including land use and land cover, to the hydrology and the likely upstream-downstream interactions and effects.
- Establish key water resources development needs of the quaternary catchment and formulate concept proposals for these.
- Establish water resources management and conservation needs in the sub-catchment and develop relevant concept proposals for them.
- Compare the results of the model with results carried out by other studies.
- Provide a linkage of the model to other models which could be on a larger scale.

Location of the Study Area

The study will be conducted in the quaternary catchments B72E, F, G and H, which forms part of the Selati River Catchment of the B7 secondary catchment of the Olifants. Part of the area falls under the former homelands. The area experiences high spatial and temporal rainfall variability that leads to seasonal dry spells. With population growth it is inevitable that pressure and competition for water supplies will increases, prompting changes in water management, allocation, and valuation.

Table 2: ***Description of the study area.***

Catchment Area: 835 km^2
Location: between 2.5^o & 26.5^o South Latitude, between 28.5^o & 24.8^o East Longitude
Population: 42205
Mean Annual rainfall:737mm

Activities within the study area

The following activities have been identified within the quaternary catchment:

Agriculture

Under this sector commercial, emerging and non-commercial farmers exist. Water sources vary from on sub-sector to the other with use of both surface and groundwater.

Domestic

The greater population found in the former homelands rely on both surface and groundwater for domestic purposes, while the commercial sector mostly relies on groundwater.

Conservancy

There are a number of conservancies which are mostly located downstream of the catchment.

All the above activities have a legitimate share to the water resources in their area hence the need to co-ordinate water abstractions and estimate the possible interactions between upstream and downstream users.

Justification

The assessment of the surface water yield will use an existing physical based model to model that can be used to report on the extent of the available surface water resources in the quaternary catchments. This will aid planning authorities in determining the feasibility of implementing water allocation activities and also to adequately plan and implement any water development strategies. It is imperative that a clear picture of available resources be developed to aid such work.

In addition, the assessment will also provide information that will allow for natural resources management as the effect of overland activities will also be incorporated in the model and the impact of upstream abstractions and activities can be easily forecasted. Of particular importance is that the time-step of the model will be of high enough a resolution to be of relevance to water sensitive activities such as irrigation- such a tool does not exist on the area of interest. Another point of interest is that the results of the model may be used to correlate land use and river flows in similar, in terms of biophysical conditions, in nearby ungauged catchments, such as the B72A quaternary catchment.

Conclusion

This research project forms a part of the CGIAR Challenge Program on Water and Food Project 17: Integrated Water Resource Management for Improved Rural Livelihoods. The entire project brings together diverse disciplines from the social sciences to the technical sciences in the true sense and spirit of integration with the intent of making meaningful contribution to rural livelihoods. The success of this component of the CGIAR Program is therefore crucial to all the other parts and shall also provide the basis of formulating tools on catchment similarities for extrapolating conclusions from one catchment to another, as will be required in the case of ungauged catchments that were chosen as 'laboratories' for the entire project.

References

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