2. Concepts and application case studies

2.1 INTRODUCTION

SADC Water Resource Database

Based initially in Harare, the Republic of Zimbabwe during 1992, ALCOM began conducting pilot activities in the member states of the Southern African Development Community (SADC). In addition to an overall goal defined as enhancing the standards of living for rural populations, the purpose of these activities was the demonstration of new techniques, technologies and methodologies for improved water resources management. Developed in conjunction with SADC host country institutions and other local collaborators, the milestone output of the ALCOM-SADC activity was the publication of the SADC Water Resources Database (SADC-WRD) in 1999.

The SADC-WRD met the above purpose comprising the innovative development and use of four primary databases: surface waterbodies, watersheds, rivers, and fresh water fish species. Controlling the integration of these databases, ALCOM used macros and other relational database[2] programming routines with the aim of providing fisheries and water resource managers with a means of producing and manipulating digital aquatic species distribution maps covering the SADC region. The production of such maps provided local managers with the ability to assess which fish species were likely to be present within a certain reach of river.

African Water Resource Database

Given the overall success of the SADC-WRD, in the third quarter of 2001 FAO-FIMA set out to expand the SADC-WRD continentally under an effort entitled the African Water Resource Database or AWRD. As an integral part of this new effort, FIMA determined that the depth of data within the archive, as well as the data management and analytical capabilities of the interface should be dramatically improved. Further, based on lessons learned during the SADC-WRD, increased benefits could also accrue to stakeholders if the expanded data and more refined tool-sets of the AWRD were not strictly limited to those purposes specifically envisioned in its design. With this rationale in mind, ESRI's ArcView 3.x GIS software was identified as the most commonly used GIS amongst stakeholders, and ESRI's open Shapefile format was adopted as the standard format for vector data within the expanded AWRD archive. All toolsets and user interfaces were developed within ArcView 3.x and therefore can be used for a wide range of tasks outside of the core AWRD functions.

Concepts and terminology used in the AWRD

Although a Glossary of Terminology and a discussion of the specific data resident within the AWRD archive are contained within other sections of this publication, it is useful to specifically introduce three key terms as they are employed within the AWRD. These three terms are: watershed, megabasin and flow regime.

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[2] A relational database system (RDBMS) is a type of database management system that stores data in the form of related tables. Relational databases are powerful because they require few assumptions on how data are related or how specific records will be extracted from the database. As a result, the same database can be viewed in many different ways.

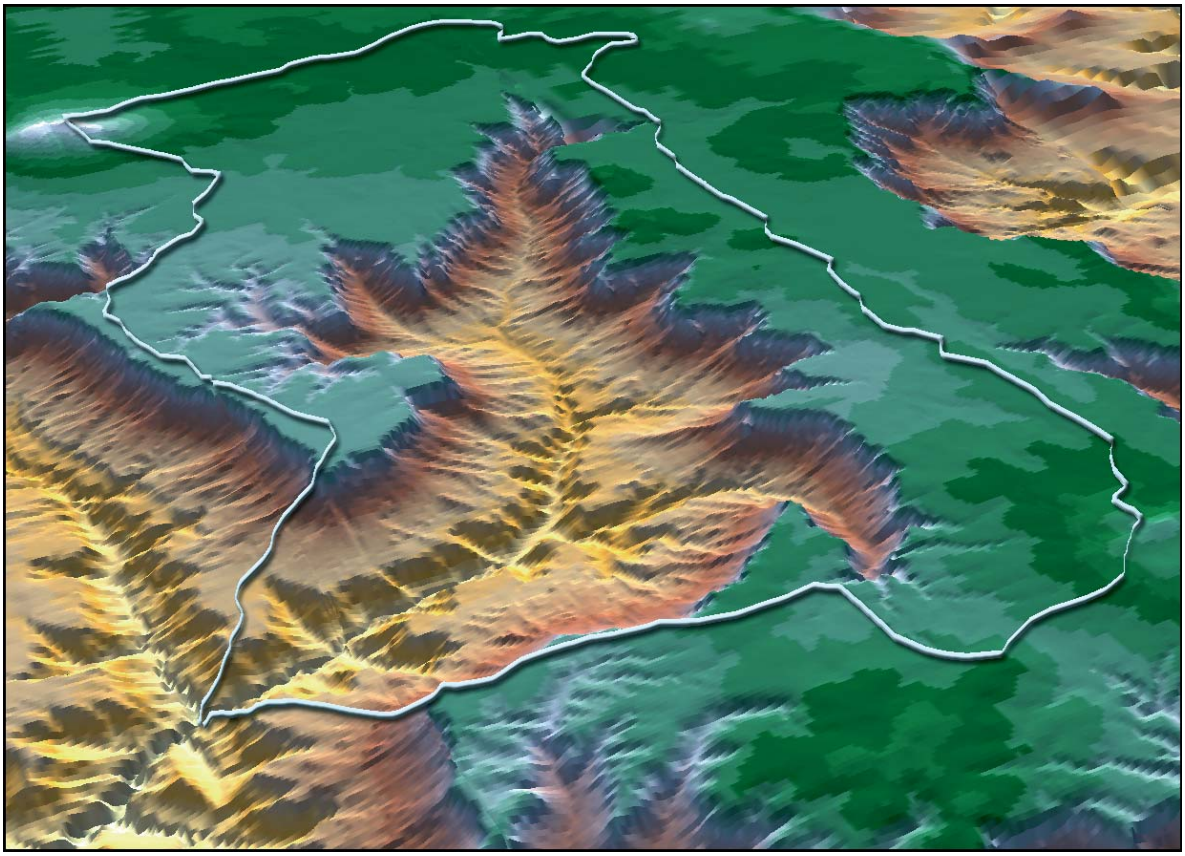
Watershed

In regards to the analysis and visualization of hydrological relationships via the AWRD the unit of choice is the watershed. Within the AWRD, the terms ***watershed***, ***catchment*** and ***drainage basin*** are synonymous with each other and are used to denote the area drained to a particular reach of river or a specific point of discharge. According to Dunne and Leopold (1978):

> A drainage basin is the area of land that drains water, sediment, and dissolved materials to a common outlet at some point along a stream channel. The term is synonymous with watershed in American usage and with catchment in most other countries. The boundary of a drainage basin is known as the drainage divide in the United States and as the watershed in other countries. Thus the term watershed can mean an area or a line. The drainage basin can vary in size from that of the Amazon River to one of a few square meters draining into the head of a gully. Any number of drainage basins can be defined in a landscape depending on the location of the drainage outlet on some watercourse.

Figure 2.1 portrays a generalized depiction of a watershed as it is used in the AWRD synonymously with the terms catchment and drainage basin.

FIGURE 2.1
Demarcation of a watershed, basin or catchment on a landscape



For most analyses dependant on physiographic or landscape factors, watersheds provide an ecologically defensible approach to the analysis of river systems at various scales and simplify the process of incorporating human and environmental impact data into any analysis. Due to this, and depending on scale, watershed units allow users to focus their analyses on specific river reaches, larger-scale river basins and at

the broadest scale, entire river systems. Within the AWRD archive, three watershed models of differing resolutions have been consolidated to facilitate the scalable analysis of individual catchments, larger basins and broader river systems.

River basins, systems and megabasins

In general usage, the term ***river basin*** is commonly used to identify the total upstream contributing area associated with a point of discharge. This point of discharge can be at the confluence of another river basin or a surface waterbody, or at either a terminal inland sink, such as a pan, or marine outflow via a lagoon, estuary or delta. In comparison, the term ***river system*** can be defined more broadly, and topologically is comprised of both the total upstream and downstream flow regime associated with a specific watershed, confluence or terminal point of discharge. In order to distinguish larger river systems at the continental scale and avoid confusion with common or local naming conventions, the term ***megabasin*** was adopted during the development of SADC-WRD to denote larger and more complex river systems.

The Nile River is an example of a megabasin and reference to this river as the Nile megabasin is often useful for continental comparisons or when it proves necessary to distinguish it from major component river systems or basins. An example of this would be a discussion requiring the separate identification of the White and Blue Nile river basins and then their differentiation of as components of the broader Nile. The following text provides an example of when a greater level of specificity would be helpful during a discussion of specific catchment areas within the context of the broader Nile.

> *The Lake George watershed lies at the uppermost reaches of the Nile river and contains the highest point in the megabasin, 4 657 meters. This watershed also represents the largest catchment area for Lake Edward and hence produces some of the largest contributing flows into Lake Albert before it joins with the Victoria Nile basin to form what is locally known as the Albert Nile. The White Nile River System is defined further downstream at the confluence of the Bahr al Ghazal and Albert Nile basins, and when joined with the Blue Nile River System further downstream at Khartoum, comes to be termed the Nile River proper as referenced in literature. In terms of the hydrological network comprising the Nile megabasin, the White and Blue Nile river systems provide the largest contributing flows.*

Flow regimes

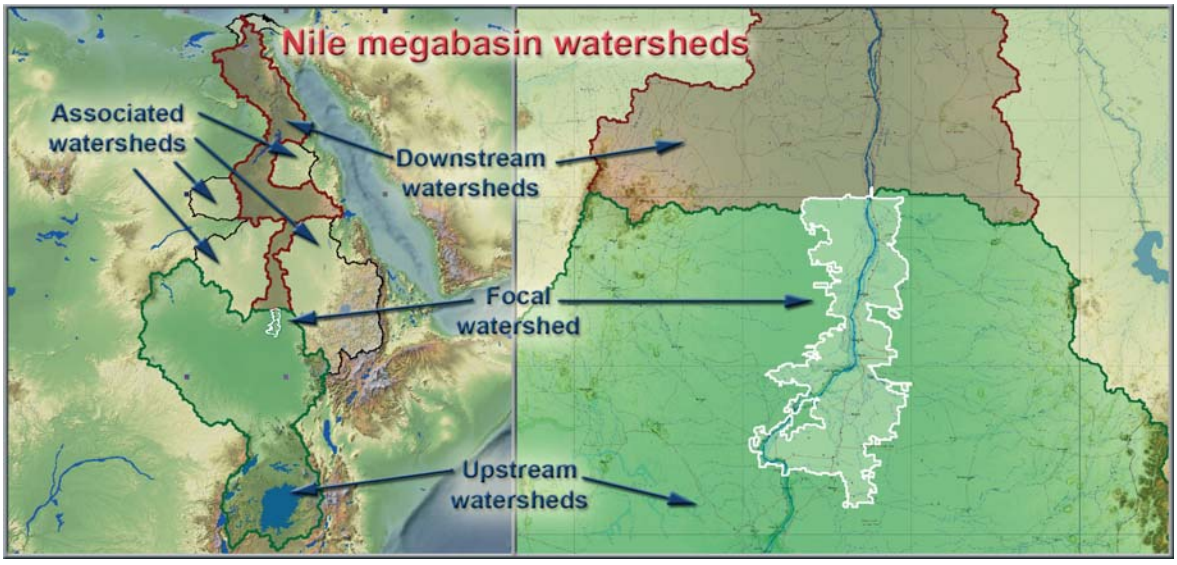
The term megabasin is used extensively within the AWRD to represent the broadest possible hierarchical unit that completely contains a network of surface hydrology. Therefore, a megabasin encompasses all tributaries, watersheds, basins and contributing river systems in such a network. In the AWRD, the term ***flow regime*** has been adopted to describe the complete network of surface hydrology within a megabasin. As used in the AWRD, a flow regime[3] represents an attempt to generalize the relationships comprising an overall network of surface hydrological into five components. For this generalization a watershed model is used as a spatial baseline from which the following collection sets are automatically created: Set 1) the focal watershed; Set 2) the upstream watersheds; Set 3) the downstream watersheds; Set

[3] The term *flow regime* as used for the AWRD is different but conceptually related to the term as used in both environmental planning and hydrology for describing stream morphology. In environmental planning, a flow regime can comprise either the whole river ecosystem or only a focal watershed, and usually concerns the influence of the: magnitude, frequency, duration, timing, and rate of change for flows in determining and maintaining habitats. For stream morphology, the term is used in association with bed formation and sediment loading based on fluid dynamics.

4) watersheds associated with a megabasin, but which are not directly influenced by flows through the focal watershed; and Set 5) watersheds not associated with or lying outside of the megabasin.

Figure 2.2, presents a visual depiction of the first four collection sets outlined above in white, green, red and grey respectively based on the selection of a focal watershed at the mouth of the White Nile River basin. At the left in the figure, the whole of the Nile River megabasin has been subset from a watershed model of Africa and its flow regime generalized based on the focal watershed highlighted at the right again in white.

FIGURE 2.2
Nile megabasin and flow regime associated with the watershed at the mouth of the White Nile River



Because the focal watershed lies just upstream of the confluence of the White and Blue Nile rivers, flows occurring below this watershed, i.e. from the east and the Blue Nile, have been classified as *associated*. With the exception of certain internally closed basins or sinks, watersheds classified as associated represent those areas of a river system that contribute base flow to the larger megabasin[4], but are not influenced by dynamics originating or passing through the focal watershed.

[4] Currently, the dependence of the AWRD on watershed models for the determination of a flow regime limits the use of the interface to surface hydrology based on polygonal watershed units.