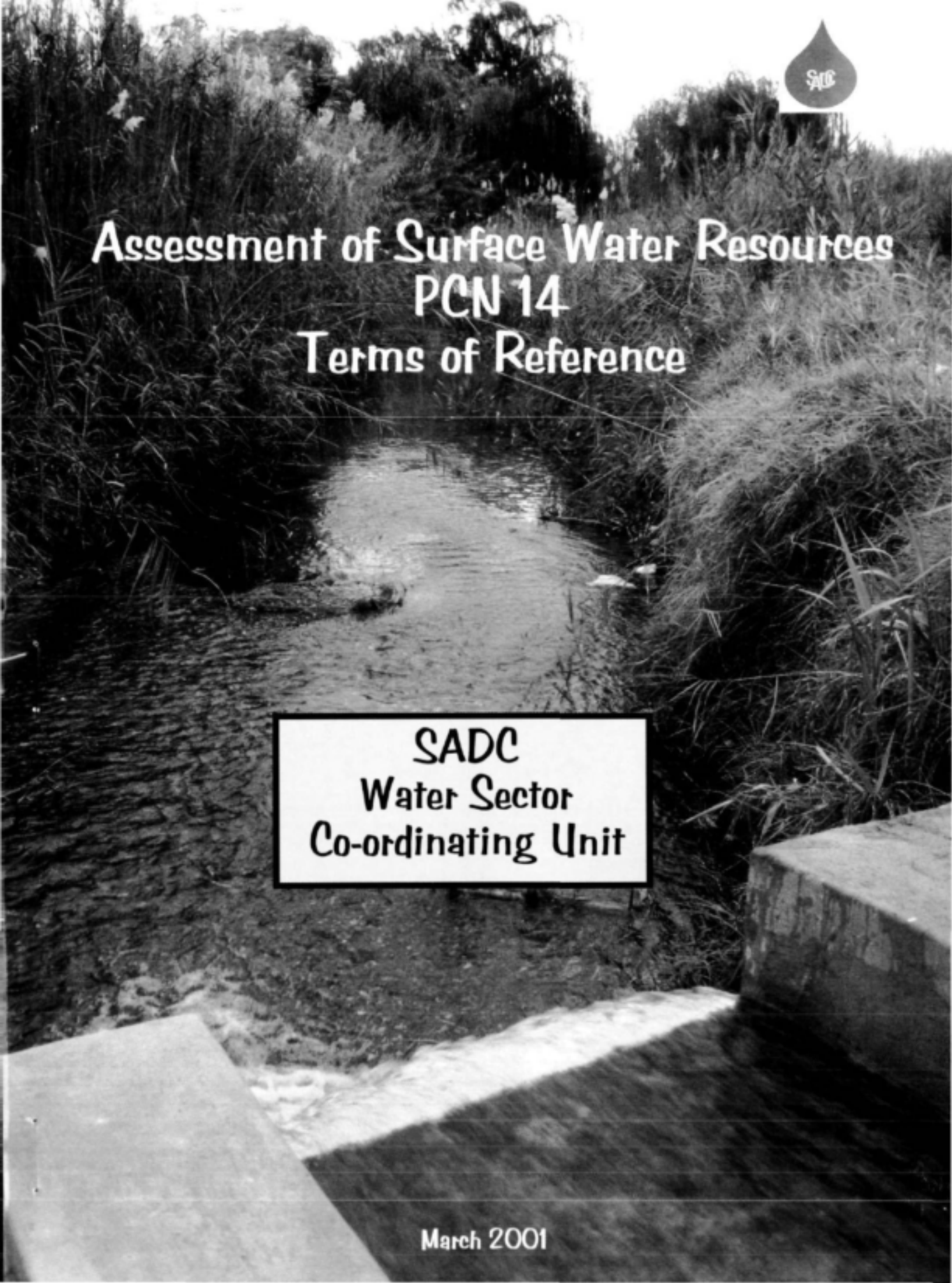

# Assessment of Surface Water Resources
# PCN 14
# Terms of Reference

SADC
Water Sector
Co-ordinating Unit

March 2001

# Assessment of Surface Water Resources
# PCN 14
# Terms of Reference

**Compiled for the**

**SADC Water Sector Co-ordination Unit**

**by the**

**Water Research Commission of South Africa**


**March 2001**

**WRC Report No: 1112/1/01**
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| | |
|---|---|
| CIDA | Canadian International Development Agency |
| CEH | Centre for Ecology and Hydrology (formerly Institute of Hydrology, UK) |
| CST | Country Study Team |
| DANCED | Danish Co-operation for Environment and Development |
| DANIDA | Denmark International Development Agency |
| DFID | Department for International Development (UK) |
| DRC | Democratic Republic of Congo |
| EU | European Union |
| FAO | Food and Agriculture Organisation (World Food Organisation) |
| FRIEND | Flow Regimes from International, Experimental and Network Data |
| HELP | Hydrology, Environment, Life and Policy (UNESCO) |
| GEF | Global Environment Facility |
| GEMS | Global Environment Monitoring System |
| GEWEX | Global Energy and Water Cycle Experiment |
| GRDC | Global Runoff Data Centre |
| GTZ | Gessellschaft fur Technische Zusammenarbeit (Germany) |
| IDGIS | Netherlands International Development Agency |
| IGBP | International Geo-sphere, Bio-sphere Programme |
| IUCN | International Union for the Conservation of Nature |
| JICA | Japan International Co-operation Agency |
| MAP | Mean Annual Precipitation |
| MAR | Mean Annual Runoff |
| NGO | Non-Governmental Organisation |
| NORAD | Norwegian Agency for Development Co-operation |
| PCN | Project Concept Note |
| RSAP | Regional Strategic Action Plan (SADC) |
| SADC | Southern Africa Development Community |
| SWMT | Study Wide Management Team |
| UNDP | United Nations Development Programme |
| UNEP | United Nations Environment Programme |
| UNESCO | United Nations Educational, Scientific and Cultural Organisation |
| UNICEF | United Nations Children,s Fund (UN International Children's Emergency Fund. |
| USAID | United Nations Agency for International Development |
| WHO | World Health Organisation (UN) |
| WHYCOS | World Hydrological Cycle Observation System |
| WMO | World Meteorological Organisation |
| WR90 | Surface Water Resources of South Africa 1990 Reports and Maps |
| WRC | Water Research Commission (South Africa) |
| WRTC | Water Resources Technical Committee (of SADC WSCU) |
| WSCU | Water Sector Coordination Unit |
| ZACPLAN | Zambesi River Action Plan |

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A preliminary discussion document was circulated during March 2000 and the following individuals and organisations are thanked for their very valuable comments, which have contributed to the contents of this document.

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A data availability questionnaire was sent out to all the National Water Agencies together with the initial discussion document. To date replies have been received from Lesotho, Mauritius, Namibia, Seychelles, South Africa and Zambia. While the content of these replies is not covered within this TOR document, the information will be very useful to the long-term study team and the effort that was put into replying is gratefully acknowledged.

During the project, two visits were made to the Maseru Offices of the SADC Water Sector Coordination Unit by members of the project team. The Director, Mr P Ramoeli and staff of the WSCU are thanked for their kind cooperation. Specifically, the visits enlightened the project team on the operation and activities of the Water Sector as well as provided access to the WSCU library containing a wealth of information on

previous water resource related reports for the region. The members of the Water Resources Technical Committee (WRTC) and Sub-Committee for Surface Water are thanked for their efforts in reviewing drafts of this document and for providing valuable comments that have contributed to the final version.

The International Steering Committee of the Southern Africa FRIEND Programme have already made some comments on the concept of the proposed study and had a further opportunity to comment on a draft of this document during the meeting held in Malawi during November 2000. Their input is gratefully acknowleged.

## PREFACE

This document represents the second main step in a process that is designed to assess and quantify the surface water resources of the whole of Southern Africa (SADC region) in a co-ordinated and unified manner, as well as building capacity within the region to make site specific water resource assessments. The first step in the process was the compilation of a SADC Water Sector Project Concept Note (No. 14) on the 'Assessment of Surface Water Resources' during 1999. The next step is to approach various funding agencies for support to carry out the long-term study that is outlined within this document. While the formal motivation for the compilation of this terms of reference document was linked to PCN 14, the Southern African FRIEND programme had also identified the need for such a study during discussions held in 1998/99 to establish the priorities for the second phase of the programme. Both PCN 14 and the recommendations of the FRIEND programme Steering Committee led to a proposal to the Water Research Commission of South Africa, which resulted in the support of a 1 year project to develop a detailed terms of reference document that could be used as a basis for proposals to major international funding agencies.

Despite the short duration of the WRC project, every effort has been made to consult with a wide variety of stakeholders in the region. An initial discussion document was circulated during March and April 2000, while a first draft of this document has been discussed by the Surface Water Sub-Committee of the SADC WRTC, as well as the FRIEND Programme Steering Committee. The authors of this report therefore sincerely hope that the contents con be considered to adequately reflect the opinions and attitudes of a broad range of individuals and organisations within SADC. This is, of course, an extremely important consideration given the regional co-operation that will be necessary to ensure the eventual success of the long-term study. However, it should be pointed out that there will be more opportunities in the future to offer comment and to modify the details of the way in which the long-term study is undertaken. A study of the type proposed must maintain a degree of flexibility in its approach, partly because of the dynamic nature of the water resource needs of the region and partly because of the large number of different organisations who have an interest in the results.

Some of the comments that have been received refer to similar, or related, studies that have been undertaken, or are currently under way, within the region. It has not been possible with the resources available to this 1 year project to fully document the results or progress of all of these activities. However, it is not the intention of this terms of reference document to ignore them, nor that past work and existing projects should be duplicated in the proposed long-term project. There seems to be general agreement that a fully integrated study over the whole region using common methodologies will have great benefits, however, it is equally certain that previous and ongoing work will have to be identified at the start of the long-term study and incorporated where possible.

The South Africa experience with the WR90 reports (a regional assessment of surface water resources for South Africa, Lesotho and Swaziland compiled during the 1990s) suggests that there are many secondary benefits associated with the availability of such information. In the years following the publication of the reports and data, it has been possible to make regional estimates of *inter alia* groundwater contributions to surface flow, environmental requirements of rivers and estuaries and the impacts of streamflow reduction activities on water availability.

A final, but very important, point is that the proposed long-term study offers enormous opportunities for the development of greater caapcity in the region in the fields of hydrology and water resource management. It is therefore essential that the capacity building components of the study are given priority consideration at all stages.

Denis Hughes
Editor

## EXECUTIVE SUMMARY

This document represents the final report of a Water Research Commission funded one-year project designed to elaborate on the issues raised in the SADC Water Sector project concept note (PCN) 14 which was entitled "Assessment of Surface Water Resources". PCN 14 stated that this assessment should build on existing work at national level, build on capacity in implementing institutions, promote confidence in the assessment products among member states and support the concepts of information access, equitable sharing of resources and environmentally sustainable water development. The report is organised into 9 chapters and 5 appendices and the content is assumed to provide the majority of the information that will be required for the compilation of proposals to specific funding agencies who may be approached to fund all or part of the proposed 10 year long term study. It has not been possible to structure this report in such a way that it can be used as a proposal to a specific funding agency as these agencies all have different format requirements.

The overall aim of the study (presented in chapter 2) is to improve the ability of the Member States of SADC to make surface water resource assessments that support environmentally sustainable development through broad strategic water resource planning that is based on information and approaches that are reliable and mutually accepted within the region. This aim is supported by five main objectives. Chapter 3 presents six points of motivation for the study which are related to the efficiency of water resource estimation, environmental sustainability, common understanding and predictable outcomes, social and economic value, global freshwater concerns and the integration of regional initiatives within SADC. *Combined, the motivations are designed to demonstrate the critical importance of the study to the* sustainable economic development if the SADC region.

Chapter 4 addresses the proposed management structure of the long-term study and discusses the project governance, as well as the management of the technical implementation. The former discusses the structures that have been established by SADC for initiating and managing projects and refers to the role and responsibilities of the implementing agent, who will provide the main interface between the SADC Water Sector structures and the consultants and contractors appointed to carried out the study. The central role that the Water Sector Coordination Unit plays in monitoring and supporting regional cooperation is recognised and it is clear that the Water Resources Technical Committee, and its various specialist sub-committees, will be expected to contribute to the steering of the long-term study.

The proposed structure for the technical implementation of the project is made up of three main components. A study-wide project management and specialist study team will be responsible for coordinating the activities of the other components and for completing any specialist work (such as database design and software development) that is applicable to the whole region. This team is expected to be active for the full duration of the project. Country study teams will be primarily responsible for the collection and initial processing of data and for preparing information for use by the basin study teams. The size of the country teams and the duration of their activities will vary and they are expected to be active during the early stages of the project. The basin study teams will be responsible for model calibration, parameter regionalisation, naturalisation, etc.; tasks which should preferably be undertaken in a basin context rather than a national one. They will also vary in size and duration of their activities and will lag behind, but overlap with, the work of the country teams. The region has been initially sub-divided into 13 major basins (or basin groupings), although it is recognised that this division may be modified after further consultation with Member States. The report offers some brief guidelines on how the various teams could be appointed and constituted and one point that is emphasised is that there should be a reasonable level of local content within the country and basin teams. This may be achieved in various ways, but is of critical importance if the capacity building objectives of the project are to be achieved.

Chapter 5 provides the details of the activities of the long-term study under six main headings, linked to the main objectives:

- General Activities
- Generation of monthly time series of river flow (Objective I)
- Developing and distributing databases (Objective II)
- Developing and distributing tools (Objective III)
- Building capacity (Objective IV)
- Improving networking (Objective V)

The general activities are largely the responsibility of the study-wide team and include a range of management activities as well as the very important task of further identifying and reviewing existing information and associated projects (see Appendix D). Existing information will be used where appropriate and collaboration with associated projects will be encouraged to avoid duplication of effort.

The responsibility for the activities related to generating time series is divided up between all the teams, as they involve data collection, database design, model development and data generation. Some of the activities are summarised quite briefly, while more detail is given for others where it has been considered appropriate. For example, guidelines on the selection of rainfall-runoff model and modelling software have been provided in some detail. The responsibility for the activities related to model calibration and validation, as well as developing and distributing databases, is divided up between the study-wide team and the basin teams (although the country teams also play a role in database development). The study-wide team will be responsible for the development and distribution of application tools (data processing, analysis and display tools as well as modelling tools). All of the teams will assume some responsibility for the capacity building activities, which are addressed in more detail in chapter 7 of the report, while the study-wide team will look after the networking activities.

Chapter 6 provides details of the proposed structure and resource needs of the long-term project, beginning with a preliminary cost and timing matrix for each of the three team groups. In summary, the total duration is expected to be 10 years and the total cost $16.27 million (at 2000 costs). $3.8 million would be required for the study-wide management team, $4.77 million for the country teams, $6 million for the basin teams and an additional $1.7 million for capacity building workshops. Chapters 6.1 and 6.2 suggests that the study should be operated over four overlapping phases, within which it is possible to identify eight funding packets. The first phase (years 1 to 3) involves the more detailed planning, review and consolidation of existing information and the development of appropriate methodolgies, software and database structures (a single funding packet). The second phase (years 2 to 6) involves the collection and initial processing of raw data at the country level. Three funding packets (management and coordination, country team costs and training course costs) are envisaged as part of phase II. The third phase (years 4 to 9) includes all the model, parameter regionalisation, flow naturalisation and regionalisation activities at the basin level. The suggested funding packets within phase III are management and coordination, basin team costs and training courses on methods and data use. The final phase (years 8 to 10) focuses on finalising the project and disseminating the results through reports and training courses (a single funding packet).

In recognition of the very great importance of developing further water resource analysis capacity within the SADC region, a separate chapter (7) has been devoted to training and capacity building. The chapter outlines several possible approaches that include internships within the contract consultant teams, participation of postgraduate students in the study, in-house training for staff of the member states national water agencies, as well as a wide range of training courses on the use of methodology and the application of products generated by the study.

Chapter 8 summarises the deliverables and critical success factors. The deliverables include database management software linked to data access, visualisation and modelling tools, the databases of time series and spatial data, guidelines to the use of the data and tools and training in the use of all the products. One of the critical success factors for a study of 10 years duration will be sustaining the funding base, while a

number of issues related to effective cooperation within the region and between the various study teams will also be important. If the region is to gain a long-term benefit from the study it is essential that the member states provide their support and that enough individuals can be identified who are interested in being trained and who remain active in the field long enough to pass on their expertise after the study has been completed.

Chapter 9 proposes some approaches to initiating the long-term study in terms of the drafting of formal proposals to international funding agencies and the initial appointment of the implementing agent and the study-wide management team.

There are a large number of potential stakeholders in the proposed long-term study and it has not been possible to document the scope of their involvement in detail. However, Appendix A lists a wide range of possible stakeholders under the categories of national water authorities, regional cooperation organisations, educational institutions, international organisations, organisations outside the region and NGOs.

Appendix B has been included as an initial guide for the next step in the process of initiating the long term study – that of identifying potential funding bodies and starting to develop formal proposals. This appendix lists a wide range of funding organisations and attempts to summarise their profiles and strategic plans so that these can be compared and matched with the objectives of the long-term study.

It has been recognised that the long-term study needs to be very focussed in its aims and objectives. However, it is equally true that the information gathered and generated during the study has the potential to have a much broader application than an assessment of water resource availability. Appendix C therefore attempts to identify some of the secondary benefits and spinoffs that the study will not address directly, but will consider during the detailed design of methodologies, databases and tools. They range from assessments of the susceptibility to extremes (floods and droughts), through links with ground water resource assessment to the quantification of flow requirements to ensure environmental sustainability. Similarly, Appendix D comprises a list of associated projects that have potential links to the long-term study from the point of view of sharing information or technologies. It is recognised by the compilers of this report that the list is not exhaustive, not are the details of possible interaction under each item complete. However, there was not sufficient time during the 1-year terms of reference project to compile this information and it is noted that the study-wide management team need to make it an early priority to identify as many links as possible to avoid duplication and to foster cooperation between associated projects within the region.

The final appendix (E) provides a draft logical framework analysis, similar to the type used by DFID to provide a summary of the measurable indicators, means of verification and important assumptions associated with the goals, purpose, outputs and activities of the long-term study.

# 1. INTRODUCTION

In November 1998, the SADC Water Regional Strategic Action Plan was presented to the international community at a Roundtable Conference. The Conference identified the need for an improvement in the knowledge and information base available for water resources management. The Conference further agreed that the presented project ideas should be expanded to full project proposals. In April 1999 an interim step was taken when a panel of experts produced a project concept note (PCN) for each of the 31 projects that had been proposed. Based on the PCNs, SADC's co-operating partners were requested to express interest in particular projects. It was anticipated that the co-operating partners would assist with the further elaboration of the PCNs into full project proposals. The purpose of the further elaboration was to clarify what was needed to be done and to present to the co-operating partners a project proposal that would contain all the information needed for the agency to consider a financing decision in the context of its strategic plans and operational procedures.

Project Concept Note 14 was entitled "Assessment of Surface Water Resources". The stated purpose is to make accessible a SADC-wide Surface Water Resources Assessment. This assessment should build on existing work at a national level, build on capacity in implementing institutions, promote confidence in the assessment products among member states and support the concepts of information access, equitable sharing of resources and environmentally sustainable water development, to which the states are committed in the SADC Water Protocol.

Concurrently the South African Water Research Commission (WRC) had agreed to finance a study entitled "The Development of a Terms of Reference for a Long Term Study to Quantify the Surface Water Resources of Southern Africa (SADC Region)". When none of the international agencies expressed firm interest in PCN 14, it was agreed that the WRC-funded study should proceed, with adjustment, to meet the need for elaborating PCN 14.

While the WRC has been able to fund this preparatory work, it has indicated that it would wish to participate in the long term study, but will only be able to provide a portion of the total resources needed. Consequently, in addition to the normal descriptive work provided in a terms of reference, this report includes *inter alia* sections on motivation for the project, a breakdown into funding packets, possible funding sources and work on the specific requirements of some agencies such as a logical framework analysis.

It is anticipated that the work presented here will be submitted to co-operating partners in the context of SADC's Regional Water Strategic Action Plan. In most cases selected project elements could, with minimal modifications, enter their financing cycles.

# 2. AIMS AND OBJECTIVES

## 2.1 Aim

The overall aim for the long term study is:

***To improve the ability of the Member States to make surface water resource assessments:***

- ***that support environmentally sustainable social and economic development***
- ***through broad strategic water resource planning***
- ***that is based on information and approaches that are reliable and mutually accepted within the region.***

## 2.2 Objectives

This aim is supported by five primary objectives.

I To generate monthly time series of naturalised riverflow at the sub-catchment spatial scale (100 to 2500 $km^2$), as well as at *major river and basin scale.*

II To develop and distribute databases of the generated riverflow and associated information (spatial data, rainfall, evaporation, water use, etc.)

III To develop and distribute tools for accessing and applying the information contained within the databases.

IV To build capacity within the SADC water resources community to make use of the developed information and tools.

V To improve inter- and intra-country, as well as international networking and to improve the ability of SADC Member States to develop water sharing programmes in a sustainable and equitable manner.

# 3. MOTIVATION FOR THE STUDY

This study is of critical importance to the sustainable economic development of the region and the main driving forces are outlined below.

## 3.1 Efficiency of water resource estimation

The development of technical and institutional capacity and the provision of database and analysis tools will improve the efficiency of water resource estimation. The study will contribute to the integration of existing national scale experience and data at the regional level. As a broad based planning tool, it will provide the basis for integrated assessments at the local and regional level and form a sound basis for future water resource management.

## 3.2 Environmental sustainability

To enable sound and consistent resource management and maintain ecological diversity and functioning, it is necessary to have sufficient information on the abiotic river environment, specifically river flows.

## 3.3 Common understanding and predictable outcomes

The development of water resource databases using common methodologies throughout the region should help to avoid conflict between member states, improve the ability to reach agreement in shared water systems and assist in the equitable apportionment of water between states or economic sectors. All of these contribute to the implementation of the SADC Protocol on Shared Watercourse Systems and also in the future to the United Nations Convention on the Non-Navigational Uses of Shared Water Course Systems.

## 3.4 Social and Economic value

There is a need for databases of water availability and existing water use to enable sound resource based planning and management in sectors other than water resource management (e.g. agriculture, power generation, rural development planning, social welfare, poverty relief, etc.). This will assist in the understanding of competitive advantages and disadvantages of the use of water within the region.

### 3.5 Global freshwater concerns

At the 1992 United Nations Conference on Environment and Development the International Community adopted Agenda 21 that provides a systematic framework for actions directed at aligning environment and development. Chapter 18 of Agenda 21 focuses on freshwater resources and their management as part of the ecosystem, providing priorities for action by the international community. Specifically in paragraph 18.12, Chapter 18 calls for activities directed at "inventoring of water resources" and the "development of interactive databases, forecasting models....". In 1994 and again in 1998 the UN Commission on Sustainable Development expressed its concern at the state of global water resource management. In 1997 the Secretary General of the United Nations reported on freshwater, noting in paragraph 19 that "national hydrological services and agencies....have become less capable of assessing their water resources" and called for renewed efforts at corrective action. Arising from the First World Water Forum, the World Water Council called, in the Marrakesh Declaration, for the preparation of a World Water Vision. This was submitted to the Second World Water Forum in Den Haag during March 2000. It highlights many concerns with the state of water resources management and calls for increased efforts by the international community.

### 3.6 Integrating regional initiatives in SADC

The SADC Protocol on Shared Watercourse Systems provides an imperative to initiate a regionally coordinated study of this nature. The time is ripe to integrate the outputs from the large number of both national and regional studies that have been undertaken within the last decade. The study will augment the benefits that have already accrued from sub-regional cooperation in the field of water resource management.

Although the study is somewhat ambitious, as well as expected to cost a substantial sum of money, the six points discussed above are believed to provide more than adequate justification for undertaking the study.

## 4. MANAGEMENT OF THE LONG TERM STUDY

### 4.1 Framework

The management of the long term study has been conceived in order to meet the objectives given in Section 2.2 and according to a framework that recognises the following realities of the SADC region :

- The SADC region is made up of 14 independent countries.
- Within the region there are local river basins (wholly within one Member State) as well as a number of large basins that are shared by two or more Member States.
- The water resource data collection, storage and management approaches differ between Member States.
- The Member States have established the Water Sector Coordination Unit to, *inter alia*, monitor and support regional cooperation.

The design of the study management approach (Section 4.3) needs to take these realities into account. The detailed scope of work and associated activities and methodologies that are required to meet the objectives are provided in Section 5. Apart from some of the technical and project specific considerations, cognisance

also needs to be taken of the established SADC protocols for water sector project implementation and funding.

## 4.2 Project Governance

With a regional project, it is particularly important that there is certainty about responsibility and accountability. The project will be implemented within the SADC Water Sector Structure. This is depicted in Figure 1. The SADC Treaty and the Protocol on Shared Watercourse Systems provide the basis of the structure. In these, the states commit to joint action and consensus decision making. This takes place within a hierarchal structure of the representatives of states both from the political and official spheres. Two SADC organs support this structure :

- The SADC Secretariat, situated in Botswana and responsible for the overall administration of SADC operations and specifically those of the Council of Ministers and the Heads of State; and

- The SADC Water Sector Coordination Unit (WCSU), located in Lesotho, is, in accordance with standard SADC arrangements, staffed by officials from the state that has been charged with the co-ordination of the particular sector.

The Heads of Government determine the overall policy and direction of SADC and delegate tasks to lower echelons. The Council of Ministers is the highest operational decision-making body and concerns itself with multi-sectoral co-ordination and particularly financial matters within SADC. It oversees the work of the SADC Secretariat and directs the sectoral minister's councils. The Council of Water Ministers is the highest and principal decision-making and supervisory structure in the political sphere of the water sector. Virtually all decisions of a non-administrative nature are taken by or ratified by the sector ministers. The chairman is the sectoral minister of the state assigned to co-ordinate the water sector (i.e. Lesotho). The WSCU provides a secretariat function to the ministers.

The Senior Officials Committee is the forum where officials that are generally the heads of the national departments prepare and agree the proposals that are put to the sectoral ministers. The Water Resources Technical Committee (WRTC) is a committee in which operational officials from the states compile and agree the technical matters in proposals that are submitted to the Senior Officials Committee. The WRTC has four topic sub-committees of which the Surface Water Sub-committee is relevant to this study.

The Water Sector Coordination Unit is charged with co-ordinating SADC activities in the water sector and with implementing the decisions of the Council of Water Ministers. The WSCU has no formal decision-making power over the substance of the proposals that are dealt with by the structures in the sector. It provides technical support and administrative and secretariat functions to all the above committees, up to the Council of Water Ministers. The WSCU is, however, not structured nor does it have sufficient resources to act as project manager for a study of the scale proposed here. It is consequently envisaged that an Implementing Agency (IA) will be appointed. The IA may be from the public or private sector. If, however, one of the funding agencies, according to its rules, may only deal with a government or government agency then a Responsible Body will be interposed. If the IA is to be a government agency such as the SA Water Research Commission, the WSCU will appoint them with the approval of the SADC structure, probably at the WRTC level, and the funders. If the IA is to be a private sector entity, or if more than one SADC public institution vies for the appointment, then the WSCU will procure the services through an open tender process that meets its own or any funders requirements.

The function of the IA is the overall management of the implementation of the long-term project that includes:

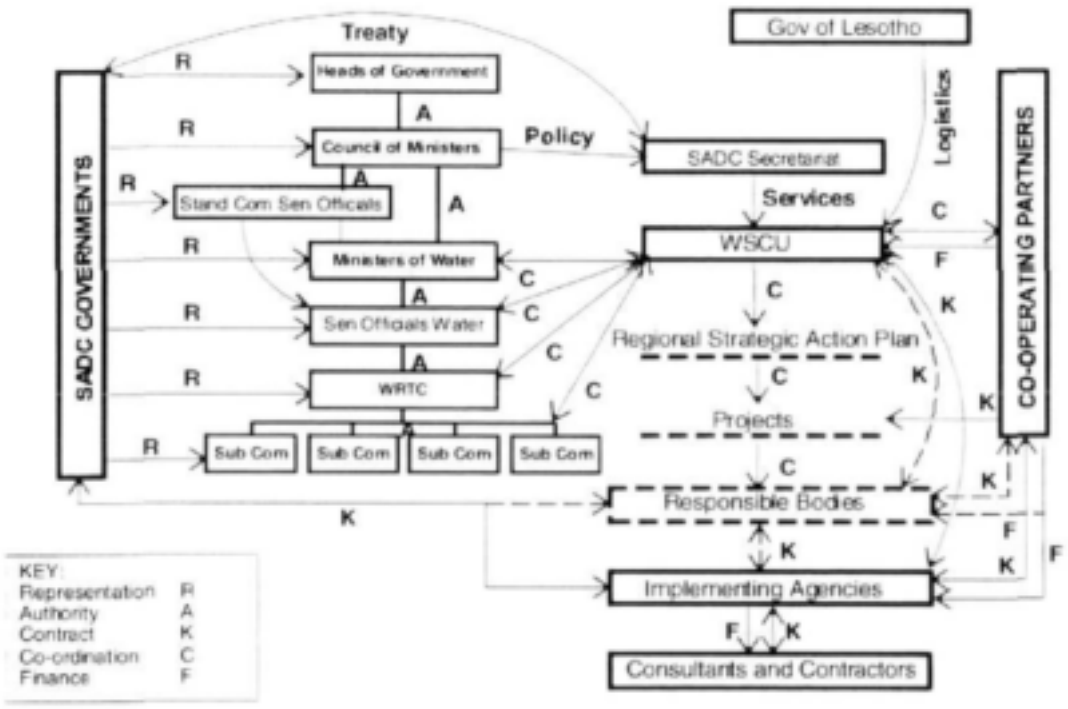
- the procurement by open tender of the services of the study-wide team;
- the procurement or supervision of procurement by the study-wide team of the country and basin

teams;

- appointment and supervision, with the agreement of WSCU and the funders, of an international review panel;
- contracting with the consultants that will undertake the work and monitoring compliance with the contract provisions;
- the arrangement of steering committee meetings (with the committees appointed by the WSCU) and other quality control measures;
- the receipt and disbursement of funds according to the rules of funders and the payment provisions in the contracts;
- facilitating, with the assistance of the WSCU and country representatives, the access of the contractors to state records;
- the provisional acceptance of project reports for recommendation to the WRTC;
- accounting to the funders, the WSCU and the SADC structures for the financial management of the project; and
- regularly reporting progress and referring any significant issues to the SADC water sector structures and the funders.

If a Responsible Body is interposed between the IA and the SADC structures, then the IA will report to it. The Responsible Body will then in turn be accountable to the funders and the SADC structures.

**Figure 1 SADC WATER SECTOR GOVERNANCE STRUCTURE**




## 4.3 Management of Technical Implementation

The proposed structure for the technical implementation of the long-term study consists of three main components; a study-wide project management and specialist study team; a country study team for each member state and a number of basin teams to cover the main drainage basins (independent of country) within the region. The detailed activities to be undertaken by these three implementation components are

provided in Section 5 where cross linkages with team responsibilities are specified.

### 4.3.1 Study-Wide Management Team (SWMT)

The IA will appoint the SWMT who will be responsible for managing the long-term study and reporting to the IA. The SWMT will also be responsible for any study-wide activities and tasks that are required, such as software development, model selection, database design, overall supervision of model calibration and parameter regionalisation, training courses and capacity building, regional liaison, etc. The SWMT will be made up of a full-time core group plus a number of specialist sub-consultants. It will remain in place for the duration of the study, but may vary in size depending upon the requirements of the project. In particular, it will need to be larger at the start of the project when many of the specialist activities are required. Within the constraints of the budget and the TOR, and with the approval of the IA, the SWMT may appoint short-term consultants or additional specialist team members to carry out the tasks for which it is responsible (see Section 5 and Table 1).

One of the responsibilities of the SWMT will be to make recommendations, towards the end of the long term study, for maintaining the resulting databases and the structures that will be required to effect regular updates of the information.

### 4.3.2 Country Study Teams (CST)

These teams will be primarily responsible for collection and initial processing of the required data (time series and spatial) and for preparing and converting (to a common format) the information within individual countries for use by the basin teams. The CSTs will be appointed jointly by the SWMT and the National Water Agency (NWA) of the individual country in consultation with the IA. For the purpose of costing, the size of the CSTs is assumed to vary from 5 full-time personnel for the larger countries to 3 for the smaller countries and that each CST will operate for a period of three years. Collectively, they will start in year 2 of the project and complete their tasks by year 6. The CSTs will be required to have a high level of local content and are expected to be based in, or strongly allied to, the National Water Agencies. However, expertise may be seconded from an outside organisation to assist in the development of capacity. The CSTs will be required to deal with country specific issues related to data availability and confidentiality. It is recommended that the SWMT and CSTs work through the SADC WSCU and associated WRTC to determine a common agreement on access to all types of data required for the study. In some cases, primary data may be considered confidential and only secondary (processed data) released to the BSTs outside the country. However, this should not cause a problem for the study as the BSTs are expected to deal with processed data.

### 4.3.3 Basin Study Teams (BST)

The total study area will be divided up into 10 to 15 major basins (or basin groups) and a BST assigned to each one. Each BST will be appointed through a competitive bidding process (either open or by invitation) in which the preferred bidder is selected by representatives of the SWMT and NWAs of the countries associated with the basin, in consultation with the IA. Tenders will be evaluated, *inter alia*, on the basis of technical expertise, proposals for training and capacity building, networking within the region and the ability to deliver results on time. The responsibilities of the BSTs will be to carry out the rainfall-runoff model calibrations, parameter regionalisation, riverflow simulation and naturalisation. For costing purposes, it is assumed that they would operate over a period of between 2 and 3 years (depending on basin size) and have a staff compliment of three. It is also possible that some BSTs may work on more than one basin.

As with the CSTs, local staff content will be required to ensure that regional capacity is developed in the use of the analysis and modelling methods. Collectively, the BSTs will start their activities in year 4 of the project and will be expected have reached completion by year 9. The actual start date for individual BSTs will be dependent upon the progress made by the associated CSTs. Liaison between individual BSTs and with the CSTs will be supervised by the SWMT.

The following preliminary subdivision of the region into 13 basins (or basin groupings) is suggested (see Figure 2). In each case the associated Member States have been identified to provide the links with the CSTs. There are clearly large differences in size, but there are equally large differences in amount of information available and intensity of water resource development activity. One of the tasks of the SWMT will be to decide what level of resources are expected to be required for each individual BST before the tendering process for the BSTs can begin.

1. Atlantic and Indian Ocean southern seaboard rivers (South Africa).
2. Orange River (Lesotho, South Africa, Botswana, Namibia).
3. Incomati, Umbeluzi and Maputo (South Africa, Swaziland, Mozambique).
4. Limpopo (Botswana, South Africa, Zimbabwe, Mozambique).
5. Okavango and Botswana rivers (Angola, Namibia, Zimbabwe, Botswana).
6. Cunene, Cuvelai and Namibian Atlantic rivers (Angola, Namibia).
7. Zambezi (Angola, Namibia, Zimbabwe, Zambia, Malawi, Tanzania, Mozambique).
8. Pungué, Buzi and Save (Zimbabwe, Mozambique).
9. Rovuma and northern Mozambique rivers (Tanzania, Malawi, Mozambique)
10. Tanzanian rivers (Tanzania).
11. Angolan rivers (Angola).
12. Congo Basin (Angola, DRC, Zambia and non-SADC states).
13. Island rivers (Mauritius and Seychelles)

Figure 2 SADC Region indicating member states (the shaded areas and excluding island members, Mauritius and Seychelles) and the identified basins using the same numbering system as in the text above.

# 5. SCOPE OF WORK FOR THE STUDY

## 5.1 Strategic Considerations

In terms of the motivation given in Section 3.3 related to common understanding and predictable outcomes, it is of strategic importance to ensure a high level of consistency and commonality of methodology and tools throughout the long term study and across the region. The following considerations are relevant to this issue:

- Use of a single rainfall-runoff model
- A common database design
- Compatible computer operating systems
- Arc/View or its derivatives as the spatial data visualisation and analysis tool.

Practical considerations determine that the outputs from this study are designed to facilitate water resource assessments at relatively large scales. Therefore, the scale of spatial disaggregation, the temporal resolution and the minimum common length for the generated river time series are as follows:

- Sub-catchment spatial scale of 100 to 2500 $km^2$ (giving a total of 10 000 to 12 000 sub-catchments throughout the region). For convenience, these are referred to as 'quaternary' catchments.
- Temporal scale of 1 month for all output time series.
- A minimum target time series length of 50 years.

In addition to general project management related activities, the scope of work for the study has been partitioned in the following Sections (5.2 to 5.7) according to the five primary objectives identified in Section 2.2 .

## 5.2 General Activities

### 5.2.1 General management (SWMT) :

The activities of the SWMT are those of general project management including:

- Project planning;
- Scheduling;
- Budgeting;
- Procurement;
- Quality assurance;
- Cost control; and
- Reporting to and liaising with the Implementing agent and Steering Committee.

### 5.2.2 Available information (SWMT):

There has already been significant water resources assessment work done in the region. The study will commence with a review of all available data and information. The SWMT will take all this work into account and avoid any repetition. In addition there are other initiatives currently underway that have the potential for duplicate work. Appendix D provides some information on potentially related projects. In collaboration with the SADC-WSCU Programme Manager, a strategy will then be negotiated with other researchers. The work plan will then be ammended to avoid repetitive or duplicate work. An important component of this activity will be the need to assess the extent to which national and regional studies can be integrated to ensure that effective co-operation on shared basins can take place in the future.

## 5.3 Activities under Objective 1 (Generation of monthly time series of riverflow)

### 5.3.1 Time Series Data Collection (CSTs):

The CSTs will collect and collate into a database (see Activity 5.4.1), all available raw time series data, including rainfall, evaporation, streamflow, dam water level/volume, water abstraction, return flow and inter-basin transfers, as well as any information on recording and processing procedures. This activity will include preliminary data integrity and quality checking. It will be necessary to determine whether a standard reference time-period can be used for all countries. However, this may not be practical and the longest possible time series should be used.

### 5.3.2 Measurement Data (CSTs):

The CSTs will collect and collate into a database (see Activity 5.4.1), all available static physical data on the hydrological and meteorological systems including stage/discharge rating curves, evaporation pan factors, stage-area-volume curves for dams etc.

### 5.3.3 Time Series Data Processing and Preparation (CSTs):

The CSTs will process and collate into a database (see Activity 5.4.1), the raw time series data. This will include formatting, quality and consistency checking, stationarity or trend checking and patching.

### 5.3.4 Spatial Data Collection (CSTs):

The CSTs will collect all spatial data, including topography, vegetation, soils, geology, land use (afforestation, irrigation, urban areas, dams, etc.), points of abstraction and return flow, sediment production, etc. Some of these data may already be available in electronic format at suitable spatial scales. It will be necessary to establish a standard format for spatial data collection and processing and ARC-Info is strongly recommended. A reference baseline year will be established for land use and water use spatial data and this year used to indicate 'present day' conditions.

### 5.3.5 Spatial Data Processing and Preparation (CSTs and BSTs):

The CSTs will process and collate into a database (see Activity 5.4.1) all spatial data that will include digitising and creation of base coverages, generation of catchment boundaries and the generation of spatial attribute coverages for catchments. Some spatial data processing (model parameter mapping, etc.) will be carried out by the BSTs.

### 5.3.6 Selection of rainfall-runoff model and modelling software (SWMT):

The model selected will be recognised as being suitable for simulating the range of catchment responses expected in the region that are caused by differences in climate, topography, geology, soils and vegetation. The model should be able to operate in a semi-distributed (sub-area) type format and should include facilities to account for the types of modification to natural hydrological regimes that are found within the region (a variety of land use changes, small and large dam impacts, direct run-of-river abstractions and return flows). It is envisaged that a limited amount of model development or improvement of an existing model will be necessary to ensure that it is suitable for the whole region. The Pitman monthly model represents an example of the type of model that would be suitable and there already exists an extensive experience base in the use of

this model in southern Africa. Therefore it is strongly recommended that this is the preferred model, although the SWMT will be required to make the final choice. Several modifications should be considered to ensure that the Pitman model is able to properly address the requirements of the long-term project. For example:

- A more flexible approach to the distribution of rainfall within the primary modelling period of 1 month to cater for differences between high rainfalls in semi-arid zones (which typically occur over a few days in a month), as well as in humid tropical zones (where the rainfall might be more evenly distributed within the month).
- An alternative, more explicit approach to ground water recharge, storage and baseflow generation that will permit improved links to ground water resource management (see Appendix C).
- An improvement in the approach to allowing for channel transmission losses, which is an important issue in semi-arid catchments, large rivers and rivers with substantial alluvial beds and floodplains.
- Improvements related to modelling semi-arid catchment processes, such as allowing for non-seasonal dynamic vegetation cover responses, as well as non-symmetrical distribution of catchment absorption rates.

Apart from model selection, this activity also includes the selection or development of software suitable for operating the model and analysing results and is closely associated with activity 5.4.1 in that the model should have a seamless interface with the spatial and time series databases. The requirements for setting up the model include the definition of the modelling area (sub-area locations, links, source of default parameter sets, source of input time series data, etc.) and facilities for editing parameter values. It is imperative that the software should include facilities to account for temporal changes in land use, physical development and water management characteristics. The requirements for analysing the results include typical time series display and analysis routines (flow duration curves, x-y scatterplots and statistical analysis of comparisons between time series, run analysis, high and low flow frequency analysis, etc.). These analysis facilities should be applicable to a user operating the model (calibrating, verifying or running scenarios), or a user who is simply analysing observed or generated time series (see Activity 5.5.1). This activity will take place mostly within the first and second years, but will be subject to review in the third year after some CSTs have started data collection and before the start of the activities of the BSTs.

### 5.3.7 Rainfall-runoff model calibration and validation (SWMT and BSTs):

This activity includes the calibration and validation of the rainfall-runoff model, including the preparation of model inputs (catchment rainfall, evaporation, land/water use, urban areas, riverflow, lakes, dams, wetlands and main stem losses) and the determination of parameter values for all catchments where adequate calibration data exist. It will be necessary to ensure that the rainfall model inputs used for the calibration exercise and the regional generation of simulated riverflows (Activities 5.3.10 and 5.3.11) are consistent.

Given that a degree of parameter interdependence is common to all hydrological models, it is possible to achieve similar outputs through different parameter sets and that single optimum calibration solutions are generally not possible. This makes it difficult to use automatic calibration procedures for deriving parameter sets that are reasonably consistent across similar catchments within a region - a requirement that is essential to ensure that Activity 5.3.9 is possible. Whether, manual or constrained automatic calibration is used, it will be necessary to establish broad guidelines, within which all the BSTs will have to operate when calibrating. It will also be necessary to supervise the teams (Activity 5.2.1) to ensure consistency and that spatial patterns of

parameter values do not contain anomalous discontinuities across basin boundaries. To avoid inconsistencies the calibration activities will be carried out over two phases. The first phase will make use of a limited data set drawn from the whole region and be carried out by a small group representing the BSTs, supervised by the SWMT. This group will establish the calibration guidelines to be followed by all the full BSTs. The guidelines could take the form of relatively simple qualitative statements, or could be quantitative parameter constraint ranges to use during automatic calibration.

### 5.3.8 Naturalisation of the observed riverflows.in calibration catchments (BSTs):

In this activity, the riverflow at each gauging station will be re-simulated by the rainfall/runoff model with all land-use components set to virgin conditions. This virgin simulation yields an estimate of the natural hydrology at each flow gauge. The difference between the simulated virgin and the historical sequence gives an estimate of the effect of all land use developments in the catchment. This information will then be used to reconstruct a time series of naturalised monthly observed flows at the gauge, from which unit MARs plotted against relevant catchment MAPs may reveal discrepancies which will be used in refining the model calibrations.

### 5.3.9 Regionalisation of rainfall-runoff model parameters (SWMT and BSTs):

The objective of this activity is to make use of the model calibration and validation results from Activities 5.3.7 and 5.3.8 to extrapolate to all quaternary catchments within the region. This will require the same generation of model inputs as in Activity 5.3.7, plus the compilation of catchment characteristics, association of relevant catchment indices with parameters and the validation of regionalised parameters. There are two possible (and not necessarily mutually exclusive) approaches:

- The more subjective approach of looking for patterns of similarity associated with spatially variable catchment characteristics (climate, topography, vegetation, geology, soils, etc.) that are expected to influence parameter values. This is more or less equivalent to defining hydrologically similar regions and assigning similar parameter sets to those regions.
- A more quantitative approach of using multiple regression analyses of catchment and climate characteristics to predict model parameters.

The SWMT will decide on the approach that is most likely to succeed in terms of producing the most representative regionalisation. The model will then be run in natural mode with the regionalised parameter set, the simulated flows compared to the naturalised flow records at the gauges, and the regional parameters adjusted until satisfactory agreement is reached.

### 5.3.10 Generation of regionalised long-term rainfall time series (BSTs):

The regionalised rainfall time series will be generated according to rainfall zones, where each zone is delimited according to a grouping of quaternary catchments. The criteria for the grouping will include topography, MAP gradients, etc.

### 5.3.11 Simulation of riverflows for all catchments (BSTs):

Using the regionalised parameter sets and long-term rainfall time series, the model will be used to generate long-term time series of synthetic riverflows for each quaternary catchment. In addition, it will be necessary to configure basin scale systems and finally generate riverflows at the main river

and basin scales.

## 5.4 Activities under Objective II (To develop and distribute databases)

### 5.4.1 Database design for both time series and spatial data (SWMT):

This activity is closely linked to Activities 5.3.6 and 5.5.1 and the critical issues to address include ease of use, portability, efficiency of access and flexibility. It is considered essential that the spatial and time series data are integrated into a single system. The best approach will be to link spatial databases (e.g. Arc/View Shape Files) with other database tables (e.g. Access, Paradox) where the time series data are stored as a single field as BLOBs (Binary Large Objects). Systems developed using Map Objects within either Delphi or Visual Basic programs are the preferred approach. This approach offers a high degree of flexibility, straightforward links to existing spatial coverages available for the region and relatively low costs of distribution to a wide range of users (licence costs for the distribution of Map Objects applications are less than $100 US). It will be necessary to consult with the National Water Authorities within the region to ensure that their requirements are incorporated into the final design specifications and that import and export routines are developed that cover the various raw data formats used.

The database design activity will have to take into account the formats of the raw data, updating of the information after the end of the long-term project, as well as the procedures and protocols that will be followed for the distribution and archiving of the data. Many of these issues are of a political, rather than technical, nature and will have to be discussed through close liaison with the SADC Water Sector structures (WSCU and WRTC).

### 5.4.2 Populating the databases (SWMT, CSTs and BSTs):

It is envisaged that the sequence of populating the database will be as follows:

- Raw data entered by the CSTs.
- Raw data used and processed by the BSTs
- Generated and synthetic information entered by the BSTs

The procedures that will be followed must ensure that exchange of information between the CSTs and BSTs is efficient.

### 5.4.3 Identification of associated products (SWMT):

Appendix C identifies a number of secondary benefits and spinoffs. This activity is designed to clarify those and specifically identify others. It will also be necessary to offer guidelines on how the information generated by the long term study can be beneficial in other fields.

## 5.5 Activities under Objective III (To develop and distribute tools)

### 5.5.1 Development of application tools (SWMT):

This will include database access tools, modelling and data analysis tools, data visualisation tools (time series and spatial data), etc. Apart from the populated databases, these tools will constitute

the main product of the long-term project. They will provide the member states (through government departments, universities and other education and research organisations and private consultants) with a wide range of facilities for making water resource estimations at a variety of spatial scales. These tools should include:

- Data import and export facilities that allow transfers of time series data to and from the range of raw data formats used within SADC.
- Data display (tabular and graphical), editing and infilling facilities.
- Modelling facilities (for assessing a variety of development scenarios, for example).
- Data analysis facilities covering a wide range of options appropriate to monthly time series data that are typically used within the region (e.g. deficient flow-duration-frequency analysis, reservoir yield analysis, impacts of streamflow reduction activities, etc.).

The tools will be structured in such a way that only a limited amount of training is required to access the basic facilities (data import and export, display and editing tools). The more advanced analysis and modelling tools will be relatively straightforward to use by hydrologists or water engineers who are generally familiar with such techniques. Activity 5.6.1 and Section 7 address the issues of training and capacity building in greater detail.

## 5.6 Activities under Objective IV (To build capacity - addressed further in Section 7)

### 5.6.1 Training and capacity building during the long term study (SWMT, CSTs and BSTs):

There are a range of possible options that can be followed including on-site training of individuals (at their place of work), internships with project contractors to facilitate training and technology transfer and more formal courses for larger groups. The development of distance learning products may also be considered. Training and capacity building activities will be coordinated with existing training initiatives and institutions within SADC (e.g. GIS training at the University of Botswana and PCN22).

### 5.6.2 Training and capacity building on products (SWMT):

The long-term study is expected to operate in phases and certain products are expected to be completed during the project. One component of the project will therefore have to ensure the rapid and effective transfer of these throughout the region. Part of this activity will have to include the development of training material (such as manuals, worked examples, etc.). This activity will also involve making recommendations about ongoing training and technology transfer after the project ends.

## 5.7 Activities under Objective V (To improve networking)

### 5.7.1 Networking (SWMT):

This will include the development of appropriate web sites and information mailing lists, organisation of conferences, symposia, workshops and stakeholder consultation meetings and the development of a study specific information service centre for the SADC Water Sector. This activity will be carried in direct consultation with SADC WSCU and in cooperation with other regional initiatives of a similar nature (e.g. WATERNET and FRIEND).

## 6 PROGRAMME STRUCTURE AND RESOURCE NEEDS

The preliminary cost and timing matrix is provided in Table 1. For the three groups of teams (SWMT, CSTs and BSTs) the table cells contain the total number of person-years required for each activity in each year. The cost per person-year is given for each team type at the top of the relevant block and includes salary costs, as well as traveling, allowances and related costs. It is assumed that the SWMT will be made up of the highest qualified staff who will be doing a substantial amount of travelling. The members of the BSTs may also be required to travel and will be specialist modellers. Many of the members of the CSTs will be based in their own country, will not be required to travel a great deal and will be mainly employed at the technician, junior engineer/scientist level. It has been assumed that any costs incurred by the Implementing Agent are covered in the budget allowed for the SWMT.

The number of person-days per year for the CSTs is based on 4 large countries each using 5 staff over 3 years, 3 medium sized countries each using 4 staff over 3 years and 7 small countries each using 3 staff over 3 years (if the island states of Mauritius and Seychelles are excluded, there will only be 5 small countries). It is assumed that the CSTs will start at different times during years 2 to 4. The number of person-days per year for the BSTs is based on 4 large, 4 medium and 6 small sized basins. The large basins will require 3 staff for 3 years, while the medium and small will require 3 staff for 2 years.

The cells in the capacity building part of the matrix refer to the number of workshops that are expected to be held under the two different capacity building activities. The costing for this section is based on the information provided in Section 7 of this document. It should also be pointed out that additional capacity building will take place within the CSTs and BSTs, through secondment of trained staff to some local offices and secondment of staff in training to some of the BSTs.

Table 1 Cost and Timing matrix (at 2000 cost levels; i.e. no allowance for inflation). The cell values represent person-years for the SWMT, CST and BST parts of the table, while the values for the Capacity Building Workshop part represent the number of proposed workshops.

| | Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Activities | | Study-Wide Management Team- SWMT (Total cost = $3,800,000 based on $100,000 per person-year) | | | | | | | | | | |
| General Management | 5.2.1 | 2 | 2.5 | 2.5 | 3 | 3 | 2.6 | 2 | 2 | 2 | 1.5 | 23.7 |
| Available Information | 5.2.2 | 1 | | | | | | | | | | 1 |
| Selection & review of model & Software | 5.3.6 | 1 | 0.6 | 0.5 | | | | | | | | 1.5 |
| Database Design | 5.4.1 | 1 | 0.5 | | | | | | | | | 1.5 |
| Associated Products | 5.4.3 | | 0.5 | 0.5 | | | | | | | | 1 |
| Development of Application Tools | 5.5.1 | 0.5 | 1 | 0.5 | | | | | | 0.5 | 0.5 | 3 |
| Training & Capacity Building | 5.6.1 | | 0.6 | 0.4 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 2.4 |
| Training on Study Products | 5.6.2 | | 0.4 | 0.2 | 0.2 | 0.2 | 0.3 | 0.3 | 0.3 | 0.5 | 0.5 | 2.9 |
| Networking | 5.7.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 1 |
| | | 5.6 | 6.2 | 4.7 | 3.5 | 3.5 | 3.2 | 2.6 | 2.6 | 3.3 | 2.8 | 38 |
| Activities | | Country Teams – CSTs (Total cost = $4,770,000 based on $30,000 per person-year) | | | | | | | | | | |
| Time Series Data Collection | 5.3.1 | | 10 | 14 | 14 | 12 | | | | | | 50 |
| Measurement Data | 5.3.2 | | 2 | 4 | 4 | 3 | | | | | | 13 |
| Time Series Data Processing | 5.3.3 | | | 8 | 10 | 10 | 8 | | | | | 36 |
| Spatial Data Collection | 5.3.4 | | 8 | 10 | 10 | 8 | | | | | | 36 |
| Spatial Data Processing | 5.3.5 | | | 4 | 5 | 5 | 4 | | | | | 18 |
| Populating the Databases | 5.4.2 | | | 1 | 2 | 2 | 1 | | | | | 6 |
| Training & Capacity Building | 5.6.1 | Included as part of the other activities | | | | | | | | | | 0 |
| | Total | 0 | 20 | 41 | 45 | 40 | 13 | 0 | 0 | 0 | 0 | 159 |

| Activities | | Basin Teams - BSTs (Total cost = $6 000 000 based on $60 000 per person-year) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Spatial Data Processing | 5.3.5 | | | | 3 | 3 | 2 | 1 | | | | 9 |
| Rainfall-Runoff Model Calibration | 5.3.7 | | | | 10 | 15 | 15 | 4 | | | | 44 |
| Naturalisation of Observed Flows | 5.3.8 | | | | | 2 | 2 | 1 | | | | 5 |
| Regionalisation of Model Parameters | 5.3.9 | | | | | 4 | 6 | 8 | 2 | | | 20 |
| Generation of Regional Rainfall | 5.3.10 | | | | | 3 | 4 | 2 | | | | 9 |
| Simulation of Riverflows | 5.3.11 | | | | | | 3 | 3 | 3 | | | 9 |
| Populating the Databases | 5.4.2 | | | | | | 1 | 2 | 1 | | | 4 |
| Training & Capacity Building | 5.6.1 | Included as part of the other activities | | | | | | | | | | 0 |
| | Total | 0 | 0 | 0 | 13 | 27 | 33 | 21 | 6 | 0 | 0 | 100 |
| Activities | | Capacity Building Workshops (Total cost = $1 700 000 based on $42 500 per 5 day workshop) | | | | | | | | | | |
| Training & Capacity Building | 5.6.1 | | 6 | 4 | 2 | | | | | | | 12 |
| Training on Study Products | 5.6.2 | | | 2 | 2 | 2 | 2 | 4 | 4 | 4 | 8 | 28 |
| | Total | 0 | 6 | 6 | 4 | 2 | 2 | 4 | 4 | 4 | 8 | 40 |

## 6.1 Phases of the Study

It is possible to recognise eight funding components (referred to in Section 6.2 as 'Packets') within four main overlapping phases of the long-term study. The duration of the phases referred to below is based on a total project duration of 10 years. Should it be deemed more appropriate to try and complete the long-term study in a shorter period the phase durations can be shortened proportionately. The four phases are briefly explained below and some of the expected deliverables for each phase are highlighted (while deliverables for the project as a whole are discussed in Section 8.1).

- Phase I (involving the SWMT) :
  Initial project planning, scheduling, budgeting and procurement for the CSTs (part of Activity 5.2.1). Review and consolidation of existing available information (Activity 5.2.2). Development of the appropriate methodologies, software and database structures (Activities 5.3.6, 5.4.1 and 5.5.1). Capacity building activities related to support of the CSTs and training in some of the methodologies, software and database tools (Activities 5.6.1 and 5.6.2). This phase extends from the start of the long-term study and is expected to be complete at the end of the third year. However, it is recognised that relatively minor revisions may be required later in the study. The expected deliverables would include database management software linked to a variety of data access, visualisation and modelling software tools.

- Phase II (involving the SWMT and CSTs) :
  Collection and initial processing of raw data at the country level (Activities 5.3.1 to 5.3.5). This phase will also include the management of the CSTs by the SWMT (Activity 5.2.1), as well as training and capacity building activities by the SWMT (Activity 5.6.2). This phase extends from (for the region as a whole) year 2 to year 6. Table 1 and Section 4.2.2 suggest that the completion year for individual countries could vary from year 4 to year 6. The expected deliverables are consolidated databases of spatial and time series information relevant to the assessment of surface water resources.

- Phase III (involving the SWMT and BSTs):
  Rainfall-runoff model calibration, verification, parameter regionalisation, flow naturalisation and regionalisation (Activities 5.3.7 to 5.3.11 and 5.4.2). This phase includes procurement and management of the BSTs by the SWMT (Activity 5.2.1), as well as training and capacity building activities by the SWMT (Activity 5.6.2). This phase will extend from year 4 to year 9 for the region as a whole, while may be completed for individual basins by year 6. The expected deliverables are the regionalised model parameters, observed and simulated time series of monthly hydrometeorological data for a standard period, regionalised water usage information, as well as guidelines for the use of both the data and the modelling techniques within the various basins.

- Phase IV: Project finalisation and results dissemination phase (involving the SWMT):
  This phase involves the compilation of final reports and product user manuals, widespread dissemination of the results of the long-term study and the organisation of training courses on the use of the study products.

Training and capacity building activities span the complete period of the long-term study and form important components of all phases. The expected deliverables are improved capacity in the region related to processing primary hydrometeorological data, analysing spatial data, interpreting hydrometeorological data, using rainfall-runoff and associated water resource estimation models and the ability to make efficient and informed decisions about water resource development options using the information and tools generated by the long-term project.

## 6.2 Funding Packets

The following eight funding packets have been identified and the preliminary costing provided in Table 1 allocated to the different packets. It will be one of the initial responsibilities of the SWMT to refine both the total required resources and the division of resources across the phases and funding packets.

6.2.1 Funding packets within Phase I

- Project initiation, management, assessment of existing information and data sources model/software development and initial capacity building by SWMT. A total of $1.625 million.

6.2.2 Funding packets within Phase II

- Management and coordination of the CSTs by the SWMT. A total of $0.710 million.
- Activities of the CSTs. A total of $4.770 million
- Training courses during Phase II (further capacity building is incorporated into the previous funding packet, through the CSTs). A total of $0.505 million.

6.2.3 Funding packets within Phase III

- Management and coordination of the BSTs by the SWMT. A total of $0.830 million.
- Activities of the BSTs (BSTs). A total of $6.000 million.
- Training courses during Phase III. (further capacity building is incorporated into the previous funding packet, through the BSTs). A total of $0.710 million.

6.2.4 Funding packets within Phase IV

- Project finalisation and training/dissemination of results and products at the end of the project. A Total of $1.12 million.

It is not suggested that these funding packets are independent of each other, they are simply one possible way of breaking the total study costs into smaller, more manageable funding units. For the long-term study to be successful, all of the activities need to be properly integrated, as do the activities that are distributed across the various Member States of SADC. One of the major issues to be considered before the project can progress and the long-term study begins (see Section 9 on the Way Forward) is to clarify the attitudes and requirements of potential funding agencies and refine the funding packet structure suggested above.

# 7. TRAINING AND CAPACITY BUILDING

There are several approaches to capacity building that should be developed during the long-term study. They all have the potential to be mutually supportive in achieving the objectives of the study. The main emphasis of all of the approaches should be to build capacity within the region to promote development in the management of water resources and the long term sustainability of the skills required for this purpose.

There are two major focus areas where the potential to develop capacity has been identified; general water resource analysis technical skills and the development of expertise in the use of the products generated by the long term study .

## 7.1 General water resource analysis technical skills.

The first major focus area is on the ability to carry out the type of technical tasks that are referred to within this terms of reference document. More specifically, this area refers to the development of skills to manage, process and analyse water resource data (time series of rainfall, flow data, evaporation, water abstraction information, etc.), skills to collect, manage and process associated data (catchment attribute data using GIS, for example) and the skills required to add value to the data through the application of different types of analysis methods or models (streamflow reduction analyses, rainfall-runoff models, reservoir water balance simulations, yield analyses, etc.). This type of capacity building is likely to apply to relatively few individuals in the region as it requires substantial resources and commitment on behalf of both the trainees' and the trainers. It is designed to expand the availability of water resource practitioners at various levels (technician through to senior engineer or scientist).

The development of such advanced skills is required to ensure that the future use and further improvement of the products generated by the long-term study can continue after the study is concluded and be carried out by personnel located within the region. There are at least two levels of training that can be envisaged:

- Training at the technician level to improve the capacity to collect, store and process hydrometeorological data. Some of this type of training can take the form of short courses and has already taken place through, for example, the FRIEND project and the introduction of HYDATA software by the Institute of Hydrology (now Centre for Ecology and Hydrology), UK. Similar training in spatial data collection, management and processing is also necessary.

- More advanced training is also required in many of the water resource analysis skills. This type of training would be better directed at the graduate engineer or scientist level and involves such skills as methods of time series analysis (trend identification, naturalisation, baseflow separation, frequency analysis, etc.), the application of models (rainfall-runoff, reservoir simulation, yield determination, etc.) as well as all the associated methods of data preparation. More advanced spatial data analysis and interpretation skills would also fall into this category.

One of the possible problems of the past has been the reliance on intensive short courses, without sufficient opportunity to practice new skills after the course, or without adequate local supervision to turn to for further development and improvement of newly acquired skills. It therefore seems essential to develop geographically distributed centres of expertise where trainees can obtain further assistance after initial training. One of the best ways to promote the success of such capacity building initiatives would be to ensure that certain regional centres are involved in the work of the long-term project from the start. This may involve extensive training at the start of the project at centres which are identified as having the capacity to develop rapidly. An alternative would be to initiate skill development through internships with project contractors, after which the interns return to their localities to continue work on the project and develop a regional centre. These approaches are not mutually exclusive and apply equally to the technician

level as well as the graduate level. Parallel development of distance learning approaches which are specifically directed at the skills required for the long-term study could also prove to be invaluable.

## 7.2 Developing expertise in the use of the study products.

The second major focus area is on the ability the make practical use of the information and data that will be generated by the long-term study and can be considered more of a technology transfer programme. This type of capacity building is likely to apply to a much larger group of individuals within the region and will be essential if the long-term project is to be considered at all successful (in as much as there is little point in generating a large quantity of data and data analysis tools if few people in the region are able to use them). This type of training will involve the interpretation of the results of the study for making practical water resource planning and development decisions, as well as training in the software tools that the long-term study will generate. This focus area is not only applicable to personnel operating within the traditional water resource sector, but should be applicable to several related sectors where the information and tools, generated by the study, could be of value. Examples might include agricultural and rural development, environmental protection and tourism development agencies.

This focus area should be directed at all levels of personnel within the region, including those who have extensive experience in the field, as well as those who are still developing experience. It will be important to maintain a programme of technology transfer throughout the project which will be largely governed by the schedule of activities under Section 5 of this document. As each activity under Section 4.2 is sufficiently developed and advanced that the concepts and practical approach can be conveyed to others, then a technology transfer action should take place through a course, or series of courses. Such an approach should also have the benefit of allowing the continuous identification of new potential participants for further detailed and intensive training (as referred to in the first focus area of capacity building under Section 7.1 above), such that they can become more active participants in the progress of the long-term study. The proposed duration of the long-term study (10 years) ensures that this type of approach is practical. It is quite likely that new trainees will enter the field of water resource management during the course of the study (encouraged by the activities of the study itself). It is also possible that individuals trained during the early stages of the study will become trainers and supervisors of others at a later stage, which will help to make the whole process of capacity building self-sustaining into the future.

### 7.2.1 Focal areas for training courses

The following list proposes some focal areas that should be concentrated on in the design of training courses :

- ❑ Monitoring and data base management
- ❑ Water resource analysis technical concepts
  - Hydrometeorological data processing and patching
  - Land use and spatial data processing and management
  - Basics of streamflow reduction quantification
  - Basics of catchment (rainfall-runoff) modelling
  - Basics of demand quantification by sector
  - Reliability (risk) concepts
  - Basics of environmental water requirements
  - Fundamentals of storage-yield-reliability
  - Basics of systems analysis
  - Basics of system operation
  - Basics of integrated water resource management
  - Basics of water economics

- ❑ The execution of the foregoing concepts as technical tasks
- ❑ The application of software and information generated by the long-term study

## 7.3 Participant organisations in capacity building

There are several types of organisations that can contribute to the capacity building process, from educational institutions (universities and other tertiary education organisations), consulting companies and NGO's to member state government departments and international cooperation, coordination and development organisations (UNESCO, UNDP, WMO, etc.).

### 7.3.1 Tertiary education organisations

These groups would be expected to play a major role in ensuring that there course material is relevant to the requirements of the region, developing post-graduate training programmes and distance learning material and facilities, encouraging active participation in the long-term study by post-graduate research students and providing facilities where short courses could be held. Universities, in particular, may also play a major role as project contractors utilising post-graduate students as trainees working on the project under the supervision of experienced lecturing and research staff. There are clearly some parts of the region where capacity development is required within the education sector itself so that they can play a more direct role in water resource training in the future. A relatively superficial survey of existing tertiary education facilities within the field of hydrology and water resource management revealed that there are a number of institutions that already offer well developed courses and others that are developing new initiatives. It will be an essential task of the SWMT (under Activity 5.2.2) to ensure that detailed information is made available on existing courses and institutions which have the potential to contribute to the long-term study.

### 7.3.2 NGO's

While no specific information is available at present, it is understood that there do exist NGOs within the region that specialise in training and capacity building programmes. Advice from such groups may be invaluable in ensuring that the courses developed during the study are focused and appropriate.

### 7.3.3 Member State National Water Agencies

State departments will need to be willing to release staff for skill development programmes, either over short periods for courses, or for longer periods to allow them to be seconded to project contractors as interns. They also need to provide a working environment that encourages in-house skill development, to support the activities of the long-term study and to encourage the use of the products generated by the study.

### 7.3.4 Project consultants

Consulting companies (acting as project contractors) need to be willing to employ interns to work on the study and to show a clear commitment to providing training. Potential project contractors should be required to clearly state their proposals for capacity building when bidding for funding to participate in the study. It will also be necessary for the project implementing agent to monitor that project contractors are actively following up on proposals for capacity building to the best of their capabilities.

### 7.3.5 International co-operation, co-ordination and development agencies

These groups may have a role to play in the organisation of regional workshops and conferences, or the sponsorship of training courses and intra-regional exchange visits. It is very difficult to assess the contributions that such groups may be able to make at this stage, but they should not be ignored

## 7.4 Budget estimate for short courses on long-term study products

It is difficult to estimate the likely costs related to the first main focus area (Section 7.1 above), but these costs are built in to the personnel task costs identified in Section 6 of this document. It is more straightforward to provide initial cost estimates for the second main focus area, although there are clearly many unknowns that cannot be quantified at this stage.

Assuming that 4 courses (at different regional centres) would be run for each group of products generated during the study and that there will be 10 groups of products, a total of 40 * 1 week short courses will be required. The costs are based on the assumption that the trainers time costs (rather than S&T costs) are covered by other parts of the study budget.

Trainer S&T costs based on 3 training staff at $300/day plus $1000 travelling costs = $7 500

Limited funding for 20 participants at $50/day = $5 000
Total S&T costs (at 2000 cost levels) for 40 workshops with limited funding = $500000

Full funding for 20 participants at $150/day + $1 000 travelling costs = $35 000
Total S&T costs (at 2000 cost levels) for 40 workshops fully funded = $1 700 000

Given the understanding that most of the course participants from within the SADC region would find it difficult to obtain funding from their employers or other sources, it is recommended that the budget figure for full funding is the most appropriate to use.

# 8. DELIVERABLES AND CRITICAL SUCCESS FACTORS

## 8.1 Deliverables

Section 6.1 outlines the Phases of the long-term study and refers to some of the deliverables that are expected during each phase. They are also summarised here for the sake of completeness:

- Database management software linked to a variety of data access, visualisation and modelling software tools. It is assumed that the facilities provided would be extremely comprehensive and would cover a very wide range of possible analysis methods that are applicable to the use of monthly time series data and associated spatial data for making water resource assessments.

- Consolidated and integrated databases of spatial and time series information relevant to the assessment of surface water resources in all SADC countries.

- Regionalised model parameters, observed and simulated time series of monthly hydrometeorological data for a standard period, regionalised water usage information, as well as guidelines for the use of both the data and the modelling techniques within the various basins.

- Training courses and manuals on the use of the software, models and database information.

- Improved capacity in the region related to processing primary hydrometeorological data, analysing spatial data, interpreting hydrometeorological data, using rainfall-runoff and associated water resource estimation models and the ability to make efficient and informed decisions about water resource development options using the information and tools generated by the long-term project.

## 8.2 Critical Success Factors

It is imperative for a project of this scope and complexity to establish critical success factors for the long-term study, without which only limited success is likely.

- Sustained funding over the full period of the long-term project. Section 6.1 refers to four phases for the project (excluding ongoing support for capacity building), while Section 6.2 refers to eight possible funding packets. These funding packets have been organised in this way to avoid the possibility, for example, of some activities being supported in parts of the region, but not in others. For a study of this type, which has a strong emphasis on regional integration, it is essential that all parts of the region are covered by the different components of the study. However, it has also been recognised that some parts of the region will generate results quicker than others, due to various capacity and data availability constraints.

- Cooperation from the national agencies responsible for the collection of water resource related information. While it may be reasonable to assume that all of the National Water Agencies will be committed to the project as they are part of existing SADC Water Sector structures, there are other agencies which the study teams will need to cooperate with to ensure the success of the project. An example is related to rainfall data, which are frequently collected by different national agencies than those responsible for water resource assessment.

- Effective cooperation between the SWMT and the SADC WSCU, WRTC and the Sub-Committee for Surface Water, particularly at the beginning of the project when it will be necessary to review existing information and integrate the results of previous, or parallel studies into this long-term study.

# 9. THE WAY FORWARD

This section outlines some of the possible steps that may be taken to achieving the ultimate objective of this preliminary Terms of Reference study. The ultimate objective is clearly the implementation of the long-term study, under the auspices of the WSCU, as a project with all the necessary funding, management and administrative frameworks that might be required for its successful execution. However, the route to achieving this objective comprises a series of crucial stages, each of which needs to be appropriately negotiated before the project implementation stage can be reached. The following sequence of stages comprises a possible way forward for the WSCU, with the support of the WRTC.

## 9.1 Stage 1: Attain a "decision to proceed" from Council of Water Ministers

Before any further progress can be made in the direction of implementation, a further round of comment and possible modification of this TOR document is required to ensure that it can be considered to reflect the views of the Member States and can therefore be presented to the Council of Ministers for approval. The steps under stage 1 are therefore as follows :

- The TOR is distributed through the WSCU for comment during the first few months of 2001 and the drafting team incorporates all critical comments into a finalised document. It should, however, be noted that the funding for the TOR project was for 2000 only and therefore the drafting team have only limited resources available for editing this document.

- The WCSU submits the final TOR document to the Surface Water Sub-Committee of the WRTC.

- The WRTC recommends a "decision to proceed" to the Council of Water Ministers, as well as any specific conditions that the WRTC might want to attach to the execution of the long-term project.

- The Council of Ministers make a "decision to proceed" and specify project conditions.

## 9.2 Stage 2: Publicise the project

The next stage should be the distribution of the TOR document (by the WSCU) to all cooperating partners (i.e. relevant Government departments, funding agencies and NGOs). The WSCU should attach a covering official explanatory memorandum to indicate that further moves toward implementation has the approval of SADC.

## 9.3 Stage 3: Procure funding

One of the issues that has been recognised by the TOR drafting team is that all funding agencies have different requirements as far as formal funding proposal formats are concerned. It was not therefore possible to draft this document in a way that will be directly applicable to any specific funding agency. A further proposal drafting step will therefore be required once potential funders are identified. It is not clear, at this stage, who will be responsible for drafting such proposals and this needs to be determined as part of stage 3. The three main components of stage 3 are therefore:

- The WCSU hosts a Funding Workshop to which all interested cooperating partners are invited. The purpose of such a workshop would be to address any problems, or issues, and identify any further requirements that potential funders may have, preparatory to drafting proposals.

- Identify the individuals or organisations that will be responsible for drafting the funding proposals

- Effective cooperation between the Country Study Teams and the relevant Basin Study Teams to ensure that issues related to data quality, for example, are communicated from the groups responsible for collection and collation (CSTs) to those responsible for modelling (BSTs).

- With respect to capacity building, one of the critical issues will be to identify enough individuals within the region who are interested in the field of water resource management to make themselves available for training. A further factor is that they remain in the field after the long-term study has been completed, to further apply their knowledge and expertise within the region.

- While data quality might be considered a critical success factor in determining whether it is possible to develop adequate regional relationships, it should also be remembered that the long-term study presents an opportunity to review existing data in a broader regional context. While it may therefore be difficult to improve on the quality of existing data for individual sites, it should be possible to ensure that only suitable data are used in the regional extrapolations. The result should be information that is of a better quality and reliability than presently exists, as well as the identification of areas where improved data are required in the future.

and agreements and appoint them to convert this TOR document into the required formats.

- ❑ Individual funding agreements are fomulated and activated.

This stage is expected to operate in parallel with the next stage (stage 4), as it is assumed that the Implementing Agent will play a major coordination role between the funding agencies and the WSCU (and other SADC structures).

## 9.4 Stage 4: Launch Implementing Agent

It will be necessary to determine from potential funding agencies whether a Responsible Body (see Section 4.2 and Figure 1) would need to be appointed to act as a direct Governmental interface for funding. The other components of this stage, which should operate in parallel with stage 3, are as follows:

- ❑ Appoint an Implementing Agent by whatever method is deemed appropriate by the WSCU and preceded by an open tender process if required. It has already been suggested that the Water Research Commission of South Africa is one possible choice as the Implementing Agent. However, the exact role and responsibilities of the IA will have to be clarified before further options can be considered.

- ❑ Establish the WSCU management interface with the Implementing Agent (and Responsible Body if required).

## 9.5 Stage 5: Launch Project Implementation via Implementing Agent

This stage involves operationalising the management interface between the WSCU and the Implementing Agent and reference is made to section 4.3 for the details of the proposed management structures for the technical implementation of the project.

## APPENDIX A STAKEHOLDERS AND ROLE PLAYERS

There is insufficient space in this document to list all the identified individual stakeholder names and addresses. This appendix is therefore limited to identifying the main organisations that either have the potential to benefit from the long term project, or who could contribute to the success of the project. This list does not include the potential funders as they are identified in Appendix B. No attempt has been made to list the many private consulting companies that have the potential to contribute to the project as it is unlikely that the project team would be able to provide a complete list.

### A1 National Water Authorities

Department of Water Affairs, Ministry of Energy and Water, Angola
Department of Water Affairs, Botswana
Secr. General Perm. Du CNAEA, Democratic Republic of Congo
Department of Water Affairs, Lesotho
Hydrological Branch, Ministry of Irrigation and Water, Malawi
Ministry of Economic Development and Regional Cooperation, Mauritius
Direccao Nacional de Aguas, Mozambique
Department of Water Affairs, Ministry of Agriculture, Water and Rural Development, Namibia
SADC Contact Point, c/o Ministry of Foreign Affairs, Seychelles
Department of Water Affairs and Forestry, South Africa
Water Resources Branch, Ministry of Natural Resources and Energy, Swaziland
Ministry of Water, Energy and Minerals, Tanzania
Department of Water Affairs, Zambia
Hydrological Branch, Ministry of Rural Resources and Water Development, Zimbabwe

### A2 Regional Cooperation Organisations

SADC Water Sector Coordination Unit, Lesotho
OKACOM
Coordination Centre for Southern African FRIEND Project, Tanzania
Zambezi River Authority, Zambia
Environment Resource Centre for Southern Africa
Waternet, Zimbabe
Africa Water Network, Kenya

### A3 Educational Institutions

University of Botswana, Botswana
University of Lesotho, Lesotho
University of Malawi, Malawi
University Eduardo Mondlane, Mozambique
University of Namibia, Namibia
University of Cape Town, South Africa
University of the Western Cape, South Africa
Stellenbosch University, South Africa
University of Port Elizabeth, South Africa
Port Elizabeth Technikon, South Africa
Rhodes University, South Africa
Fort Hare University, South Africa
University of Transkei, South Africa

University of Natal, South Africa
Zululand University, South Africa
University of the Witwatersrand, South Africa
University of Pretoria, South Africa
Rand Afrikaans University, Pretoria
University of the North, South Africa
University of Zenda, South Africa
Potchefstroom University, South Africa
University of the Free State, South Africa
University of Swaziland, Swaziland
University of Dar es Salaam, Tanzania
University of Zimbabwe, Zimbabwe
Institute of Water and Sanitation Development, Zimbabwe

## A4 International Organisations

Food and Agriculture Organisation (FAO)
Global Water Partnership
UNESCO, Kenya
United Nations Development Programme (UNDP)
World Meteorological Organisation (WMO)
World Bank
African Development Bank
Development Bank of Southern Africa

## A5 Organisations outside the Region

Centre for Ecology and Hydrology, UK
IRD, France

## A6 Others

Water Research Commission, South Africa

## A7 NGOs

International Rivers Network, Botswana
Group for Environmental Monitoring, South Africa
Environmental Monitoring Group, South Africa
International Union for the Conservation of Nature (IUCN), Zimbabwe
Okavango Liaison Group, Botswana WaterNet, Zimbabwe

## APPENDIX B POTENTIAL FUNDERS

The SADC Water Regional Strategic Action Plan was presented to international co-operating partners at a Roundtable Conference in November 1998. It was agreed that the project ideas should be expanded to full project proposals. In April 1999 an interim step was taken when a panel of experts produced a project concept note (PCN) for each of the proposed projects. The subject of this report is PCN 14. On this basis the co-operating partners were requested to express interest in particular projects. It was anticipated that the co-operating partners would assist with the further elaboration into project proposals of those PCN's in which they had expressed interest in a manner that met the procedural requirements of their institutions. By mid 2000 this was underway.

None of the agencies expressed firm interest in PCN 14. The analysis in this appendix consequently seeks to build on the elaboration of the project and to identify elements in the strategic plans of the regionally active agencies that indicate a match with the project elements described in this report. The researchers have structured the project information such that with minimal adjustment the procedural requirements of any of the agencies could be met.

The match of these project proposals with the strategic plans of the co-operating partners rests on the following propositions:

- Water resource assessment is a pre-condition for effect water resource management;
- Knowledge about water resources is a key element in SADC regional inter-state co-operation on water resources management;
- Water is a key resource in environmental management especially in the semi-arid conditions experienced in most SADC states;
- The project success depends on and is structured to ensure extensive capacity building in the hydrological observation and analytical departments of the governments;
- Since most of the river basins are shared between several states, comprehensive water resources assessment is impossible without inter-state co-operation;
- Agenda 21 Chapter 18, identifies water resource assessment as one of the focus areas for action and calls for an extension of data collection and analysis of water resources;
- Successive international forums such as the UN Commission for Sustainable Development (CSD6) and the Second World Water Forum have called for increased understanding of water resources and their management;
- The international development agencies seek to implement the outcomes of these international forums; and
- The project is multi-faceted and from its scope will probably require several support agencies on state, basin or topic lines.

The following sub-sections identify some of the International Agencies Active in the SADC Water Sector.

### B1 African Development Bank (AfDB)

The AfDB is essentially an investment financier but does have a technical assistance and capacity building programme. No further information is available at present.

### B2 Belgium (Source: SADC Water Roundtable Statement)

Belgium has a general cooperation agreement with SADC within which water is a priority, more specifically sectors such as water and sanitation, capacity building, education and training. Belgium is also concerned with water legislation, implementation of the Protocol on Shared Watercourse Systems and

sectorial policy and strategy. Current projects relate to the Drought Monitoring Centre and small water bodies for aquiculture and fisheries. A fund for capacity building is envisaged.

### B3 Canadian International Development Agency - CIDA (Source: http://www.acdi-cida.gc.ca)

CIDA is active in Swaziland, Mozambique, Zimbabwe and South Africa. It has been concerned with wetlands, hydrology, hydro-power at the regional level. Canada's official development assistance program concentrates resources on six programme priorities. Those of importance to this project are:

- *"**Infrastructure Services**: to help developing countries to deliver environmentally sound infrastructure services with an emphasis on poorer groups and on capacity building; and*
- ***Environment**: to help developing countries to protect their environment and to contribute to addressing global and regional environmental issues."*

Africa and Middle East Branch is one of CIDA's four geographical branches and it has a division for southern Africa. CIDA devotes the highest share of its resources to Africa. While the programme is "firmly rooted" in key selected individual countries, support for regional initiatives is set to grow as they assume greater importance. The Branch's priorities are the reduction of poverty and the promotion of peace and security. Emphasis is also placed on combating desertification and promoting sound environmental management.

### B4 Denmark International Development Agency - DANIDA (Source: Final draft: Policy paper on water resources management, Ministry of Foreign Affairs, May 2000.)

DANIDA is currently active in Tanzania, Zimbabwe, Mozambique, Malawi, South Africa as well as with Zacplan. The fundamental principle of Danish development assistance is sustainable poverty alleviation. One of its three cross-cutting themes is the promotion of environmentally sustainable development and protection of the global environment. From this the objective of DANIDA's water resource management policy is derived to be:

> *"to support integrated and efficient water resources development and management that contributes to long-term environmentally sustainable economic and social development and specifically, enhances the right of access to the resource by the poor and vulnerable groups and empowers these to improve their livelihood".*

Support will chiefly be provided as a sector support programme focused on certain countries and with an emphasis on capacity building. The operational scope is described in five 'blocks' one of which is the development of adequate monitoring, information and decision systems. These could be at regional, country or sub-national scale. At the international level DANIDA seeks to co-operate with other organisations. The policy paper further identifies capacity building and information, monitoring, research and technology development as specific policies and strategies.

### B5 Danish Co-operation for Environment and Development - DANCED (Source: http://www.mst.dk/danced)

DANCED is active in the environmental field in Namibia, Tanzania, Zambia, Zimbabwe, Botswana and South Africa and has assisted at basin level with Zacplan. The assistance at national level is based on individual strategic country papers. DANCED functions under the auspices of the Ministry of Environment

and Energy and co-ordinates activities with DANIDA. It is part of the Danish environmental initiatives in developing countries and its initial efforts have been in the southern African and south east Asian regions.

The overall objective is to contribute to the restoration of the global environment with key priority areas of urban development, sustainable forest management, biological diversity and coastal zones. These areas are strongly based on alignment with identified Danish expertise.

At the regional level the Danced strategy directs its efforts towards problems of a transboundary nature and where other agencies are co-operating. The forms of possible assistance include monitoring of the environment, data collection, support for international conventions and capacity building. Potential regional efforts include the optimal exploitation of water resources at a regional level as part of a programme to reduce natural resource degradation.

### B6 Deutsche Gesellschaft fur Technische Zusammenarbeit (GTZ)

Active in South Africa, Zambia, Zimbabwe.

### B7 Department for International Development (DFID - UK)

DFID is active in the water sector in Namibia, South Africa, Zimbabwe, Mozambique, Lesotho, Tanzania, Zambia and supports the FRIEND project.

DFID aid is directed in general terms by the British Government's, 1997 White Paper on International Development: Eliminating World Poverty: A Challenge for the 21st Century. With the theme of poverty elimination, water and food are identified as an important component. As far as the former is concerned the policy is to support "international efforts through the United Nations, other agencies and bilaterally to implement key principles for sustainable integrated water management as set out in Agenda 21...". Within a commitment to adopting a comprehensive framework the focus is on the delivery of safe water and community empowerment while treating water as both a social and economic good. The White Paper also commits DFID to environmental sustainability and regeneration.

At the water sectoral level DFID has published a consultation document entitled, Strategies for Achieving the International Development Targets: Addressing the Water Crisis. DFID will work principally with governments as the decision-makers in resource allocation but also commits to wider alliances inter alia with civil society. It will use its particular strengths through responses in supporting institutional transformation, promoting best practice and generating and sharing Knowledge. Further:

> *"4.6.9 Effective water governance requires through scientifically accurate information about the water domain to be compiled and made widely available. The collection, analysis and open sharing of water resources data is of vital importance if a balanced water future is to be a reality.....Baseline information is especially important."*

However in the specific actions listed under the above responses there are only very indirect links to the type of basic functions envisaged in the assessment project.

### B8 European Union - EU (Source: http://europa.eu.int)

The EU is supporting SADC-HYCOS, SATAC of the Global Water Partnership (GWP) and the implementation of the SADC Water Protocol. EU support is directly linked to the LOME Convention and represents practical co-ordination where joint action of its member states is needed. EU channels fifteen per cent of the aid provided to ACP countries by its member states.

*"EU action is founded on three priority areas of support and three guiding principles. The first area of support comprises growth factors, development of the private sector, competitiveness and employment. The second concerns social policies, access to basic services and food security. The third concerns support for regional cooperation and integration, to which the EC continues to assign special priority.*

*The Union has also defined three guiding principles which should be routinely taken into account in all kinds of Community support. First, political, administrative and institutional reforms should be encouraged and support given for capacity building at government level or at more decentralised levels, for example enabling economic operators and social players to form representative bodies. A second guiding principle entails promoting, in all spheres of the partnership, a gender-sensitive approach based on the reduction of disparities between men and women, notably by carrying out the necessary impact studies and encouraging the implementation of positive action. The third principle guiding the Union is that sustainable management of the environment and natural resources is part and parcel of the development process. Showing concern for the environment is not a luxury, it is often a key element in combating poverty."*

### B9 Global Environment Facility - GEF (source: http://www.gefweb.org)

GEF has provided funds for water related projects on Lake Malawi, Lake Victoria and the Okavango Delta. GEF was established as a "*mechanism for international co-operation for the purpose of providing new, and additional, grant and concessional funding to meet the agreed incremental cost of measures to achieve agreed global environmental benefits in the areas of....international water.....*". The key criteria for eligibility are that the proposal must reflect national or regional priorities and must improve the global environment or advance the prospect of reducing risks to it. Countries must achieve eligibility through accession to international conventions.

The operational strategy directs GEF's efforts in four focal areas and ten operational programmes. The focal area of potential importance to this project is "International Water" and within this are operational programmes number 8 "Waterbody-based Operational Programme"and number 9 "Integrated Land and Water Multiple Focal Area". A further possible link is with Operational Programme Number 12: "Integrated Ecosystem Management" within the "Multifocal Area". GEF envisages that it will fulfill a catalytic role in restoring or protecting waterbodies but will only be a small part of the overall programme.

Although there is a focus on international co-operation and the determination of baseline actions, this project would have difficulty fitting into the programme scope, envisaged interventions or types of activities of any of the three operational programmes. The only potential intervention is listed as "*8.9(d) encourage the use of sound science and technological innovations for management*". Further work would be needed to examine the basis for GEF including on the Mekong River Basin project a project component on basin modelling and analytical tools that include inputs such as hydrological modelling and supplemental data collection, surveys, monitoring and mapping.

### B10 Japan International Co-operation Agency (JICA)

Active in South Africa. No further information at present.

### B11 Norwegian Agency for Development Co-operation - NORAD

(Source:http://www.norad.no and http://odin.dep.no)

NORAD is active in the water sector in Tanzania, Zambia, Zimbabwe, Namibia. It is concerned with wetlands, Zacplan and rural water supply.
NORAD=s policy in the water resources sector is to integrate the environment into Norwegian development assistance and to contribute to sound management of the global environment and biological diversity. Four main environmental areas have been given priority:

- ❑ Development of sustainable production systems
- ❑ Conservation and sustainable use of biological diversity
- ❑ Reduced pollution of soil, air and water
- ❑ Preservation of cultural heritage and management of of the natural environment's cultural values.

Development assistance should help to strengthen international cooperation in order to address the global challenges facing the world by:

> *AThe environmental priorities in this strategy entail a greater focus on the sustainable use of natural resources and biodiversity instead of classical protection.*
>
> *2.2.1 Development of sustainable production systems and management of natural resources*
>
> *Water use plans should cover entire catchment areas and include mapping, monitoring, analyses, a clarification of property and user rights to and the future use of water resources. Measures for a better and more efficient use of fresh water should be supported@*

### B12 Netherlands International Development Agency - IDGIS (Source: Policy Priorities for Netherlands development Assistance, Volume 2, Ministry of Foreign Affairs, July 1998.)

IDGIS is active in the water sector in Mozambique, Zimbabwe, Lesotho, Tanzania and Zambia. It has been concerned with wetlands and the Zacplan. The Netherlands Development Assistance (NEDA) policy framework identifies three key challenges namely, poverty alleviation, enhancement of equity and sustainable ecosystems maintenance. Within this, one of the focal points is the development of integrated water resources management (IWRM) approaches. The NEDA support programme is grouped into two spheres of actions.

Firstly in the sphere of building institutional capacities the priorities are institutional capacity at the local level that seeks to empower communities, human resources development, awareness raising, and international dimensions in areas such as river basins. Furthermore initiatives in research, information and technology development are supported that have foci on creating national and regional capacities and generating information and analyses that support IWRM.

Secondly, NEDA supports the sphere of water uses and functions within which ecosystem maintenance is a key aspect.

### B13 Swedish International Development Agency - SIDA (Source: http://www.sida.se)

SIDA is active in Angola, Mozambique, Namibia, Zimbabwe, Zambia, Tanzania and Botswana. It is also involved in awareness and education programmes, shared rivers, SADC-WSCU, OKACOM, Zacpro 6 and ZAMCOM. Within the overall goal of Swedish development co-operation to raise the standards of living of the world's poorer groups, SIDA has as one of its specific objectives "*the long term sustainable management of natural resources and the protection of the environment*". SIDA integrates environmental aspects into all development co-operation programmes in accordance with the undertakings ensuing from Sweden's accession to Agenda 21. SIDA gives priority to supporting the management of scarce water

resources.
SIDA as one theme promotes knowledge as the key to development. In this context it gives priority among others to human development in public administrations and promotes knowledge about issues that may prevent conflict. On the latter topic it has supported research into the potential for conflict over water resources in southern Africa. A characteristic of SIDA's operations is that it seeks to promote networks as demonstrated by its hosting and financial support of the Global Water Partnership and its close co-ordination with the European Union and other multilateral and bilateral agencies.

SIDA has developed a special initiative on sustainable water resources in southern Africa. This initiative is said to be catalytic in nature in order to stimulate additional investments in the sector. It aims to achieve improved planning and understanding of water resources by inter alia supporting research and development of methodologies for integrated management of water resources. It secondly aims at improved management of water resources by supporting environmental surveying and the work of river basin commissions.

### B14 United Nations Development Programme (UNDP)

The UNDP has supported the SADC Water Round Table process in accordance with its mandate for capacity building in national and regional institutions. It is the lead institution directing the UN Secretary General's Special Initiative on Africa.

### B15 UNICEF

The WMO is a constituent organisation of the United Nations system concerned with children in development. UNICEF is active in all the SADC states. Part of its activities relate to water and sanitation services.

### B16 United States Agency for International Development - USAID (Source: http://www.usaid.gov)

USAID is the federal agency that manages US foreign economic and humanitarian assistance programmes around the world. It has a number of programmes but in the context of this project any assistance would be provided through the development assistance account. In SADC, USAID operates from the Regional Center for Southern Africa situated in Gaberone. It is active in Zambia, Malawi, Swaziland, Mozambique, Lesotho, Angola, South Africa and Tanzania. It has supported the implementation of the SADC Protocol on Shared Water Courses. It also supports the SADC-ELMS initiative on Environment Information Systems. Concerned with Sector Assessment, SADC-WSCU at the regional level.

USAID seeks to achieve sustainable development through six interrelated goals that include building human capacity through education and training and the protection of the environment. USAID structures its programme in a strategic heirarchy. Apart from capacity building the structure relevant to this project is:

Goal 5: The world's environment protected for long term sustainability.
Objective 5.5: Sustainable management of natural resources increased.
Programme Approach 5.5.1: Management of forests, water resources and coastal zones improved..

The Initiative for Southern Africa (ISA) is USAID's regional approach for supporting the SADC states and links to the special Development Fund for Africa. It includes a natural resource management element.

### B17 World Bank

The World Bank is active in the water sector in Angola, Malawi, Namibia, Mozambique, Lesotho, South Africa, Zimbabwe, Zambia. It was also the lead institution in the SSA Hydrological Assessment. The World Bank is essentially an investment financier but does have a technical assistance and capacity building programme. No further information at present.

### B18 World Food Organisation (FAO)

The FAO is a constituent organisation of the United Nations system. It is not a funding agency per se but provides facilitation and technical support to member states and regional initiatives on matters relating to food and food security. Its interest in the water sector is established by the role of irrigation in food security.

### B19 World Metrological Organisation (WMO)

The WMO is a constituent organisation of the United Nations system. It is not a funding agency per se but provides facilitation and technical support on hydrological matters to member states and regional initiatives. It is active in SADC-HYCOS.

### B20 Other Partners that attended the Water Roundtable Conference

Finland, France, India, Italy, Portugal, Switzerland

Christian Aid, Development Bank of Southern Africa, Group for Environmental Monitoring, International Union for the Conservation of Nature (IUCN), International Academy for the Environment, United Nations, Habitat, Unesco, UNEP, WHO.

## Appendix C SECONDARY BENEFITS AND SPINOFFS

It is recognised that the long-term study needs to be very focused on the stated aims and objectives. However, it is also recognised that the development of the various databases and technologies could lead to related initiatives. This section is therefore designed to identify some of the benefits that could result from the long-term study which are not directly associated with the objectives. It is possible that some additional work may need to be undertaken within the long-term study to maximise these benefits and there is therefore some overlap between this appendix and Section 5 which outlines the scope of work.

### C2 Secondary benefits associated with environmental flow requirements

The need for environmentally sustainable water resource management and the quantification of environmental or ecological flow requirements of rivers and estuaries is receiving increasing international attention and within the SADC region. South Africa has recently modified its water law to account for such requirements, while Zimbabwe, Namibia and Moçambique have also started to develop guidelines for conserving the ecological status of water bodies.

Experience suggests that it is very important to understand what the reference abiotic conditions were in rivers which are now subject to water resource developments (through the construction of reservoirs, the development of distributed run-of-river abstraction schemes and land use changes). One of the major components of the abiotic condition of a river is the flow regime and the results from the long-term project will provide a sound database of time series of natural riverflows plus information on the current levels of water resource development and land use modification.

It is not the express purpose of the long-term project to develop procedures and software for the determination of environmental flow requirements. However, it would be extremely useful if the SWMT could ensure that the data generated by the study is compatible with any methods being used within the region to establish environmental flows. This will be an issue related to activity 5.4.1 (database design).

### C2 Secondary benefits associated with Ground Water resource assessment

The assessment of ground water resources is not expected to be included directly in the study and forms part of a parallel SADC Water Sector initiative (PCN 6: Groundwater Management Programme for the SADC Region). However, there are important links between surface water and ground water, which should not be ignored, and a relatively small amount of additional effort undertaken as part of this proposed study could be extremely beneficial. Two specific areas where important links have already been identified are ground water recharge and the ground water contribution to streamflow.

#### C2.1 Ground water recharge

One of the necessary components of the long-term project will be the compilation of monthly rainfall time series for each identified quaternary catchment within the region. In addition, spatial coverages of topography, soils, vegetation, land use and geology will also be compiled. All of this information is required for the successful estimation of recharge, but additional work will be required to develop a procedure for recharge calculations. This procedure could be developed as a separate 'model', or the rainfall-runoff model chosen for use in the long-term study to generate riverflows could be modified to include a method for ground water recharge estimation. Some of the issues related to recharge estimation are also referred to in the following section.

#### C1.2 Ground water contribution to streamflow

The South African experience suggests that what surface water hydrologists refer to as 'base-flow' (which is commonly estimated using some graphical procedure to separate the high amplitude quick-flow response of a river, from the lower amplitude base-flow response) is not always equivalent to what ground water specialists would recognise as being contributed from the ground water body. This may be related to the fact that base-flow response in river flow regimes includes drainage from the sub-surface zone lying above the phreatic surface. Such processes might include drainage from temporarily saturated soils, perched water tables and drainage along fracture zones that are temporarily saturated and where the drainage vector has a major horizontal component (such as in areas of steep topography). Water that is considered to be ground water 'recharge' from a surface hydrologists view point (i.e. vertical drainage past the soil zone) may therefore not reach the true ground water table and become 'recharge' from a ground water hydrologists view point.

If the long-term study is to include an assessment of the ground water contribution to streamflow, the above issues need to be resolved and incorporated into any techniques that are developed to carry out the estimations. As with recharge estimations, a separate model could be used, but it may be preferable to modify the rainfall-runoff model chosen for the main study to include components that will allow the ground water contribution to be estimated. It is important to recognise that a complex rainfall-runoff model would not be appropriate to the proposed study and any enhancements related to ground water interactions would necessarily be relatively simple and take into account the type of information available for parameterisation. However, if ground water interactions are to be included, this will have to be considered when choosing which model to use and adapt, as not all models would lend themselves to the type of modifications referred to.

## C3 Secondary benefits associated with drought susceptibility

The time series of monthly rainfall and river flows that will be generated as part of the long-term study will have an almost direct benefit in terms of the assessment of regional susceptibility to drought. It will be straightforward to identify periods of below average rainfall and river flow and to assess their regional extent within the context of SADC as a whole.

## C4 Secondary benefits associated with flood susceptibility

While the long-term study will be based on a monthly time resolution of information, the raw data are at a daily resolution in most countries and will have to checked for quality before they can be summed to monthly. The first potential benefit from a flooding perspective will therefore be related to the quality control of raw rainfall and flow data. A further benefit relates to the type of estimation equations frequently used for estimating floods with different return periods. These are often based on physical catchment information of the type that will be compiled as part of the spatial data collection programme, as well as mean annual statistics of rainfall and flow which will be obtainable from the simulated natural time series.

## C5 Secondary benefits related to daily modelling and using daily time series data

While the long-term study will concentrate on the simulation of monthly river flow time series, much of the raw data will be collected and checked in the form of daily data. In addition, the regionalisation of monthly model parameters and associated compilation of physical catchment data will provide background information for further studies related to the use of daily hydrological simulation approaches. There are existing research initiatives within the region that are attempting to use extensive data sets of monthly time series data, together with limited daily data, to generate more geographically widespread information on the characteristics of daily flow regimes. The results of the long-term project will provide additional

impetus to such research efforts in that regionally compatible SADC-wide monthly data will be made available.

### C6 Secondary benefits associated with the adequacy of hydrometeorological gauging networks.

While it is not the express purpose of the long-term study to evaluate the hydrometeorological gauging network within the region, it is inevitable that information and comments on the adequacy of the network will be generated by the study. This information may then be used by other projects to provide motivation for the establishment of new gauging stations or the revision of member states networks.

## Appendix D ASSOCIATED PROJECTS

This list is intended to identify projects and programmes of a regional or international scale that may have linkages to this study whether through the sharing of data, the use of consistent database structures, techniques or processes. It is possible that the associated projects may contribute to the long-term study, or that the proposed study may make a contribution to the associated projects. However, the project team accept that this list is by no means exhaustive and that one of the tasks of the long term study team will be to carry out a detailed survey of available information to avoid duplication and to ensure that previous studies are added to, rather than repeated.

### D1 SADC Regional strategic action plan

This assessment project is part of the SADC Regional Strategic Action Plan. The Plan includes a comprehensive range of projects that are directed towards improving regional co-operation in water resources planning and management. It is intended that all of these projects will be undertaken in parallel with this project under this guidance of the SADC Water Sector Coordination Unit. The purpose of listing some of them here is to reinforce the imperative that duplication of work is to be avoided. In a sense they all have relevance to this project but those more directly linked are (Source: Project Concept Notes):

#### D1.1 Project No 3. Capacity building for Joint River Basin Management

The broad objective is to improve national and regional capacity in joint river basin planning and management. More specific objectives include the strengthening of existing river basin institutions, guidelines and procedures, information acquisition and sharing and capturing lessons learnt to increase institutional memory. The objective links strongly to the capacity building objectives of the assessment project.

#### D1.2 Project No 4. Consultative Forums on Water Issues

The core objective is to involve stakeholders from government, river basin organisations, support providers from universities and consultancies and organised civil society in regular and purposeful consultative and capacity building forums. One element of this that has already been launched is the "Water Weeks" organised by the SADC-WSCU in each of the states. In addition regional and basin-level forums are envisaged. This project will provide useful mechanisms for consultation activities on the assessment project.

#### D1.3 Project No 6. Groundwater Management Programme (GMP) for the SADC Region

Whereas the project that is the subject of this TOR concerns surface water, the GMP is the comparable groundwater programme. The physical link between surface and ground water is patent and many would argue that their analysis should not be separated. Nevertheless there are compelling institutional and discipline specific issues that have led to the separation in the SADC-RSAP. The GMP has advanced significantly and has already been partly funded. The GMP has ten constituent projects dealing with capacity building, standards, information systems, monitoring networks, mapping, establishing a research institute or commission, publicity and three characteristic aquifer resource assessments. Most of the generic components of the programme have equivalents in the surface water assessment and it will be critical for the latter firstly not to repeat generic work and secondly to ensure maximum linkages through aspects such as capacity building and data structures.

D1.4 Project No 15. Expansion of SADC-HYCOS.

The SADC-HYCOS (Hydrological Cycle Observation System) project is a component of the international WHYCOS programme of the WMO. It is concerned with the capture of real-time hydrological data and has been successfully operating in several SADC states for a number of years. The project has links to the assessment project through technical aspects such as data formats, observation calibration and through institutional aspects such as technical capacity and information sharing.

D1.5 Project No 16. Regional Project to Control Infestation and Translocation of Aquatic Weeds.

This project concerns itself with data gathering, scientific study, international strategy and cooperation, legislation and public awareness concerning aquatic weeds.

D1.6 Project No 17. Training in Surveying, Mapping and Geographic Systems.

The objective of the project is to increase regional capacity in the core topics of water resource management such as aerial photography, satellite imagery, geophysics and geographical information systems (GIS). A number of initiatives in this project are already underway notably GIS training in Botswana. This project also links strongly to the programme of SADC Environment and Land Management Sector (ELMS). The capacity building elements of the assessment project will have to integrate with this project.

D1.7 Project No 22. Human Resources Development Programme

This project addresses the general human resource needs of the water sector in SADC. The objective is to develop and implement a human resource development plan for water resources institutions in the region.

## D2 Zambesi River Action Plan (ZACPLAN)

Zacplan was initiated in 1985 by the then frontline states organised as SADCC with the objective to promote environmentally sound water resources management in the Zambesi River System. Zacplan is constituted by 19 projects (so-called Zacpros). Initially it was coordinated by SADC-ELMS and now by SADC-WSCU. Zacpro 6 has now largely become the responsibility of the Zambesi River Authority (ZRA). The whole plan is now under review.

The projects of interest to the assessment project are:

- Zacpro 3 & 4 : Development of human resources, administrative and institutional structures and technical capabilities
- Zacpro 5 : Development of a basin-wide, unified monitoring system related to water quality and quantity (now absorbed into Zacpro 6).
- Zacpro 6 : Development of an integrated water management plan for the Zambesi River.

Of particular importance to the assessment project is the first phase of Zacpro 6 concerned with the establishment of Zacbase. The objective was to establish a database system for "the collection, processing, analysis,storage and retrieval of mainly hydrological, hydrometeorlogical and water quality data". The well-established HYDATA programme has been used as the main port of data entry. The system has been

designed as a screen-operated, interactive tool for database management, data quality control and editing, river system description, graphical presentation of records and export of data and basic statistics. The Zacbase is now installed at ZRA but at May 2000 was experiencing technical difficulties. The further phases of Zacpro 6 are:

- Phase 2 : Development of simulation models and simulating various development senarios. A consortium of Nordic funders was formed but it appears that Sida will take the inititive.
- Phase 3 : Identification of a draft action plan
- Phase 4 : Implementation.

## D3 National projects

There are potentially a large number of national projects that will be of relevance and support to the long-term project. However, it is assumed that these will be identified by the Country Study Teams more accurately and successfully than was possible during the initial 1-year TOR project.

## D4 World Meteorological Organisation

The WMO has many programmes and projects that are relevant to this project. They are mostly of a general nature but may provide specific guidelines on techniques or data. The World Meteorological Organization is involved in the implementation of one of the priority programmes of United Nations Special Initiative on Africa (UNSIA) under water namely, "Expand Fresh Water Assessment". The strategy developed by WMO for the implementation of this priority programme is tied to the follow-up to the recommendations of the WMO/ECA Conference on Water Resources in Africa: Policy and strategy (Addis Ababa March 1995), and to the implementation of the WMO World Hydrological Cycle Observing System (WHYCOS) and its regional and sub-regional Hydrological Cycle Observing System (HYCOS) components. Mali, Ethiopia, Uganda, Mozambique and the Zambezi River Basin were selected by the working group of the water cluster of UNSIA for concerted UN agency water cluster activities under the Initiative.

### D4.1 Constituent bodies and major programmes

- Commission for Hydrology
- Regional Working Groups on Hydrology
- Programme on Basic Systems in Hydrology
- Programme on Forecasting and Applications in Hydrology
- Programme on Sustainable Development of Water Resources
- Programme on Capacity Building in Hydrology and Water Resources
- Programme on Water-related Issues

### D4.2 Projects

- WHYCOS and SADC-HYCOS
- HOMS
- INFOHYDRO
- STEND
- Comprehensive Fresh Water Assessment

#### D4.2.1 WHYCOS

WHYCOS is a global programme, modeled on the WMO's World Weather Watch. It has two components:

- A support component, which strengthens cooperative links among participating countries.
- An operational component, which achieves "on the ground" implementation at regional and international river basin levels.

WHYCOS is based on a global network of reference stations, which transmit hydrological and meteorological data in near real-time, via satellites, to NHSs and regional centres. These data enable the provision of constantly updated national and regionally-distributed databases, of consistently high quality. WHYCOS aims to support, in all parts of the world, the establishment and enhancement of information systems that can supply reliable water-related data to resource planners, decision makers, scientists and the general public.

WHYCOS does not replace existing hydrological observing programmes, but supplements them (see the benefits of WHYCOS). An important product of WHYCOS is regional datasets that are of consistent quality and can be used in preparing products for water resources assessment and management. However, WHYCOS has been conceived, perhaps more importantly, as a vehicle for technology transfer, training and capacity building. WHYCOS is being developed in the form of regional components, HYCOSs, which meet the priorities expressed by the participating countries. In its initial phase WHYCOS has focused on establishing components in international river basins, in the catchment areas of enclosed seas, and in regions of Africa that are poorly served by hydrological information.

### D4.2.2 SADC-HYCOS (Source: http://www.wmo.ch/)

This project covers the 11 continental countries of the Southern African Development Community (SADC). Its implementation started in 1997 with the 2.40 million US$ grant from the European Commission funding. The Regional Centre is hosted by the Directorate of Hydrology, Department of Water Affairs and Forestry (DWAF) in Pretoria, South Africa. Technical Assistance (TA) is provided under a contract awarded to the Institute of Hydrology (IH) (Wallingford U.K.). IRD (France) has been sub-contracted by the IH for the development of the SADC-HYCOS information system. Several of the data stations were severely damaged during the February 2000 floods.

## D5 FRIEND (Source: http://www.pangea.org/orgs/unesco/friend/home.html)

The FRIEND (Flow Regimes from International Experimental and Network Data) research programme is an international study in regional hydrology. Its aim is to develop a better understanding of hydrological variability and similarity across different regions through the mutual exchange of data, knowledge and techniques. Such knowledge is vital to improve practical water resource and flood design methods. FRIEND is currently Project 1.1 of UNESCO's fifth International Hydrological Programme (IHP). From a relatively modest beginning in 1985 with scientists from just four European countries, the project has grown considerably and now involves research institutes, universities and operational agencies from over 90 countries around the world. There are seven international FRIEND projects in operation.

Objectives:

- To develop the understanding of the spatial and temporal variability of hydrological regimes using regional data sets for the support of global scale hydrological research and the development of risk procedure analysis.

- To develop the upstreaming of regional models, so as to compare them with process models, generally built from local scales, and so contribute to a more relevant disaggregation of regional knowledge.
- To sustain observations networks by a contribution to the development of relevant data bases having improved "easy-to-use/high-technology" ratios in collaboration with WMO.

Products:

- Data sets for global scale Hydrological modeling,
- Reports on regional flow regimes.
- Proceedings of international workshops and conferences.

The Southern Africa FRIEND Project was initiated in 1990 and includes organisations from 11 countries in Southern Africa. The Southern Africa river flow archive contains river flows from 680 catchments in 11 countries. A comprehensive range of spatial information is also held, including river basin boundaries, digital elevation, river network, precipitation, evaporation, soil, geology and land use data. The most recent report, published by UNESCO in 1998, describes the results from Southern Africa FRIEND. An important feature of future FRIEND projects in developing countries will be training and capacity building.

Southern Africa FRIEND has entered a second phase and the project to prepare this document has been accepted as a component of the programme. The programme is overseen by a Steering Committee made up of representatives from the SADC Member States. The Centre for Ecology and Hydrology (CEH) in the UK has secured funding from DFID for 2000 to 2003 to support the Southern Africa FRIEND programme. The research to be carried out under this project is expected to include:

- Application of a grid based water resource availability assessment approach within the region.
- Development of regional low flow analysis methods.
- Assessment of the water balance of selected lakes within the region (including Lake Nyasa/Malawi).
- Assessment of rainfall-runoff model parameter regionalisation procedures in two major basins within the region.

All of these sub-projects include components of capacity building and have the potential to make contributions (as pilot studies) to the long-term study proposed by this TOR document.

### D6 Global Runoff Data Centre -GRDC (Source: http://www.bafg.de/grdc.htm)

The GDRC is located in the Federal Institute of Hydrology, Germany. What follows is an information note provided by GDRC. A global hydrological database is considered essential for research and application-oriented hydrological and climatological projects at global, regional and basin scales. This includes water balance studies, investigation of trends in long-term hydrological time series, coupling of hydrological and meteorological models, flux of fresh water and pollutants into the oceans, and the coupling of runoff with water quality data. Monitoring of runoff is indispensable for water resources planning and management on all scale levels. The principal objective of the GRDC is to collect and disseminate hydrological data to support projects within the World Climate Programme (WCP) and the World Climate Research Programme (WCRP) of the World Meteorological Organisation (WMO) as well as for other programmes such as the World Hydrological Climate Observing System (WHYCOS) of WMO and the World Bank and the Global Environment Monitoring System - Water (GEMS-Water) of UNEP and WHO. The Centre provides a mechanism for the international exchange of data pertaining to river flows on a continuous, long-term basis. The scope of data collection is global, regional and on catchment

scale.

Operating under the auspices of WMO gives the GRDC the UN mandate and an identity with regard to the United Nations system that is essential for its international recognition. Hydrological and Meteorological Services of Members of WMO on a multilateral and bilateral basis are the principal data providers for the GRDC.

At its Twelfth Congress, the World Meteorological Organisation (WMO) adopted Resolution 40 (Cg-XII) and thus committed itself, as a fundamental principal, "to broadening and enhancing the free and unrestricted international exchange of meteorological and related data and products." In this context, "free and unrestricted" means non-discriminatory and without charge, the latter with the meaning "at no more than the cost of reproduction and delivery, without charge for the data and products themselves." With regard to the Global Runoff Data Centre, Congress also adopted Resolution 21 (Cg-XII) that encourages Members (countries) "to support the GRDC through the provision of the hydrological data and related information that it needs".

WMO Congress also adopted the practice that countries "should provide to the research and education communities, for their non-commercial activities, free and unrestricted access to all data and products exchanged under the auspices of WMO" with the understanding that the commercial use of these data may be subject to conditions. Resolution XII-4 (Paris, September 1996) of the UNESCO Intergovernmental Council for the International Hydrological Programme (IHP) "Invites Member States to review their policies for the international exchange of hydrological data so that they may be supportive of the research being undertaken on major global issues" and further "Requests the IHP National Committees to work with their national Hydrological Services to provide the scientific community with access to hydrological data and information needed for research at regional and international levels... using the internationally recognized international data centres".

General criteria for data collection are: Data should be collected for rivers which reflect the hydrological regime of a region or part of a country, rivers which are economically important in terms of population density and/or agro-based or industrial production and those rivers which drain into the oceans or have an internal drainage. Preferably mean daily discharge data of good quality and long time series of discharge are favoured for entry into the database.

As a principal GRDC policy, the responsibility for the quality of data lies with the national hydrological services. The GRDC performs plausibility tests and communicates with the data providers. The GRDC has been formally established at the Federal Institute of Hydrology in Koblenz, Germany in 1988. The Hydrology and Water Resources Programme (HWRP) in WMO is the professional contact partner for the Centre. The activities of the Centre are monitored by the international Steering Committee of the GRDC which provides advice on the functions of the GRDC, policy matters, data acquisition, services and the implementation of various tasks.

The Centre operates on the basis of a state-of-the-art Databank Management System which ensures fast data entry and retrieval services, complex queries and fast response to data requests. The database is continuously updated. So far, 147 countries contributed to the development of the database which now consists of data from over 3.600 stations monitoring about 2.900 rivers worldwide. Within its limited resources the GRDC is offering a range of advisory services to national hydrological services as incentive to provide data. Furthermore a collaboration in the field of database technology is offered to national and international organisations.

The Centre provides users with information for the proper selection of data with regard to the objectives of the client. The collection of project databases and the provision of data products is performed on request. An important service is the feed-back information for the national hydrological services about the use of

the data. The GRDC-catalog can be requested free of charge. The GRDC encourages researchers to use the GRDC database for studies and research in direct collaboration with the Centre and the Centre is prepared to invite and accept guest researchers.

### D7 Global Precipitation Climatology Project - GPCP (Source: http://www.bafg.de/grdc.htm)

The GPCP is located in the Federal Institute of Hydrology, Germany. What follows is an information note provided by GPCP. The task of the Global Precipitation Climatology Project (GPCP) is to provide the climate research community with gridded datasets of monthly precipitation totals based on observational data. The specific GPCC functions are defined by the 'Implementation and Data Management Plan for the Global Precipitation Climatology Project' (WCRP 1990, WMO/TD-No. 367) and comprise:

- Acquisition, collection, and organized storage of precipitation data from surface-based networks;
- Quality-control and assessment of the collected resp. used data, correction of errors;
- Calculation of gridded area-mean monthly precipitation for the earth's landsurface;
- Error assessment for the precipitation totals on the individual gridcell;
- Combination of the gridded monthly precipitation data from surface-based and satellite observations (this item is performed jointly by all GPCP components);
- First steps are taken to derive daily precipitation totals based on GTS - SYNOP data;
- New GPCC functions have been defined in the framework of the Arctic Climate System Study (ACSYS);
- Development of an Arctic Precipitation Data Archive (APDA) including daily precipitation and snow depth data;
- Calculation of area-mean precipitation series for Arctic river basins;
- GPCC also performs comparison studies for gridded precipitation datasets from different sources (surface or satellite based observations, model results, climatologies from various authors). Furthermore, the GPCC applies its analysis system for special studies, e.g the El-Nino precipitation anomalies in winter 1997/1998.

### D8 The Global Land One-km Base Elevation (GLOBE) Project (Source: http://www.ngdc.noaa.gov/seg/topo/globe.shtml)

The Globe Project is located at the National Geophysical Data Centre (NGDC) of the National Oceanic & Atmosphere Administration (NOAA) of the US Department of Commerce. It is a co-operation with the National Aeronautics and Space Administration (NASA). The Committee on Earth Observation Satellites established the GLOBE Task Team. It is part of Focus 1 of the International Geosphere-Biosphere Programme (IGBP) - Data and Information System. The GLOBE project has developed a 1-km gridded, quality-controlled global Digital Elevation Model (DEM).

### D9 Global Freshwater Quality Monitoring Programme - GEMS/Water (Source: http://www.cciw.ca/gems/)

The GEMS/Water programme is a multi-faceted water science programme oriented towards understanding freshwater quality issues throughout the world. Major activities include monitoring, assessment, and capacity building. The implementation of the GEMS/Water programme involves several United Nations agencies active in the water sector as well as a number of organizations around the world.

### D10 International Geo-sphere Bio-sphere Programme (IGBP)

This is a programme of the United Nations Environmental Programme (UNEP). Its focus is on the interaction between environment and global climate change. A workshop was held in October 1999 in Nairobi to discuss how research from the IGBP and the International Human Dimensions Programme (IHDP) could contribute to African water resources. The two sub-programmes of IGBP that may be of interest to this study are:

D10.1 Biospheric Aspects of the Hydrological Cycle - BAHC (Source: http://www.igbp.kva.se/bahc1.html)

The BAHC addresses the effects of biologically influenced land surface properties on the water cycle and the Earth's heat budget. The BAHC project includes: patch scale observational and modeling studies of soil-vegetation-atmosphere transfer processes; regional scale studies of hydrological fluxes and other land-atmosphere interactions; spatial and temporal synthesis of biospheric parameters at the regional to continental scale; and the down-scaling of weather information from GCMs, for application to ecosystem research. Many of these studies involve close collaboration with the World Climate Research Programme (WCRP) Global Energy and Water Cycle Experiment (GEWEX), and high priority is given to ensuring complementarily between BAHC and GEWEX activities. The BAHC International Project Office is situated at the Potsdam Institute for Climate Impact Research.

D10.2 Land Use and Cover Change - LUCC (Source: http://www.igbp.kva.se/lucc.html)

The Land-Use/Cover Change project is jointly run with the International Human Dimensions Programme ( <http://www.igbp.kva.se/research.html> IHDP) on Global Environmental Change. It addresses how land use, and thus land cover and surface properties, is affected by socio-economic factors, and aims to integrate the driving forces of land-cover change into a global land-use and land-cover change model. The LUCC International Project Office is situated at the Institut Cartogràfic de Catalunya, Spain.

**D11 Global Energy and Water Cycle Experiment - GEWEX** (Source: http://www.gewex.com/)

The Global Energy and Water Cycle Experiment (GEWEX) was initiated in 1988 by the World Climate Research Programme (WCRP) to observe and model the hydrologic cycle and energy fluxes in the atmosphere, at the land surface, and in the upper oceans. GEWEX is an integrated program of research, observations, and science activities ultimately leading to the prediction of global and regional climate change. The goal of the GEWEX Program is to reproduce and predict, by means of suitable models, the variations of the global hydrological regime, its impact on atmospheric and surface dynamics, and variations in regional hydrological processes and water resources and their response to changes in the environment, such as the increase in greenhouse gases. GEWEX will provide an order of magnitude improvement in the ability to model global precipitation and evaporation as well as accurate assessment of the sensitivity of atmospheric radiation and clouds to climate change. The International GEWEX Project Office (IGPO) is located in Maryland, US.

**D12 Unesco initiative on hydrology, environment, life and policy - HELP** (Source: http://www.pangea.org/orgs/unesco/wat19/W19News.html)

In December 1998, a UNESCO-sponsored meeting of international water experts was convened at the Institute of Hydrology, Wallingford, UK, in response to, and in the light of, several recent international conferences and documents on freshwater issues. The purpose of the meeting was to consider the need for

a new experimental hydrological research initiative to deliver the scientific basis for future sustainable water management.

HELP is presently in concept form only. The broad objectives of HELP are to strengthen field-oriented, experimental hydrology using the drainage basin (10,000 to 100,000 km2) as a framework. Water-related physical (hydrological, climatological, ecological) and non-physical (technical, sociological, economics, administrative, law) observations will be made in these catchments which address the most critical policy and management issues as perceived by "users" under different biophysical and socio-economic environments, taking into account needs for sustainable development. Therefore, the principal point of entry for the Task Force will be the use of the World Water Vision 2000 (management/policy) scenarios.

If this new programme is to be truly "user-driven" the active involvement of both policy and facilitating (water and land resource managers) groups is required to set the policy agenda and ensure that the scientific results will benefit societal needs. HELP is also intended to be a pro-active programme in terms of anticipating future water issues, which require a longer-term strategic vision, rather than being solely reactive to current environmental problems.

### D13 USAID Southern Africa Regional Water Sector Assessment (Source: Project Report by Stanley Consultants (Project 690-0280) July 1995)

This study was undertaken within the context of USAID's programme in southern Africa. Phase 1 of the study focussed on the gathering and collating of all available information and documents pertaining to water resources in the region. The output of this work was a catalogued collection of over 1000 documents. The documents are now housed at SADC-WSCU in Maseru and the report provides lists by classifications such as topic, country etc. Part 2 of the study was analytical work directed at USAID's programme.

### D14 The Watershed Database for sub-Equatorial Africa (Source: Alcom working Paper No 16, Harare, 1998)

The Aquatic Resource Management for Local Community Development Programme (Alcom) is a regional aquatic resource management initiative of the FAO. It covers the continental SADC except the DRC. The programme developed a watershed model based on a digital elevation model and the river layer of the Digital Chart of the World. The purpose was to delineate exactly the different drainage regions. It was primarily directed delineating potential boundaries for aquatic species and a need for digital fish distribution maps. The Watershed Database and the complete Water Resources Database have however been developed into a much more versatile tool for general water resources management. The data are available on CD-ROM and the system is maintained by Alcom from Harare.

### D15 Sub-saharan Africa Hydrological Assessment, SADCC Countries.

This project was funded in the late 1980s by the World Bank and the UNDP.Country reports were prepared for most SADC states and are dated January 1990. A regional report was published in 1993. The purpose of the project was to evaluate the status of all existing hydrological data, networks and collection systems and to recommend improvements.

## APPENDIX E Draft Logical Framework Analysis

| NARRATIVE SUMMARY | MEASURABLE INDICATORS | MEANS OF VERIFICATION | IMPORTANT ASSUMPTIONS |
|---|---|---|---|
| **GOAL**<br>Improved management of the water resources of the SADC region in an environmentally sustainable manner | Co-operation between states<br>Status of environment<br>Increased utilisation of resources | Favourable reports in SADC and elsewhere<br>Views of eg SADC-ELMS, IUCN and others<br>UN statistics, service coverage, agriculture and power output | On-going evaluation programmes of the performance of the sector are instituted |
| **PURPOSE**<br>Improved ability of the member states to make surface water assessments based on information and approaches that are reliable and mutually accepted within the region | Increased water resources assessments of shared water course systems.<br>WR Assessments based on proposed models<br>WR assessments undertaken by SADC based agencies | Published information.<br>Reports in SADC Water Sector and basin commissions. | The SADC Water Protocol is implemented and the proposed river basin commissions are established |

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| **OUTPUTS**<br>1. Monthly time series of riverflow at the sub-catchment spatial scale (100 to 2500 $km^2$, suggesting 10 000 - 12 000 quaternary catchments in total), as well as at major river and basin scale. | Published data | Every river system in the SADC region has a published monthly riverflow. | |
| 2. Distributed databases of the generated riverflow and associated information (spatial data, rainfall, evaporation, water use, etc.) | Access to data bases and information | Every national hydrological department and river basin commission has the data on its computer files. | |
| 3. Tools for accessing and applying the information contained within the databases. | | Published information | |

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|---|---|---|---|
| 4. Capacity within the water resources community to make use of the developed information and tools5. Improved inter and intra country, as well as international networking | The analytical tools are freely available and understood.<br><br>Tertiary education institutions teach and research the tools<br>The techniques are used by government departments and agencies. | Frequency of courses<br>Frequency of use | |

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|---|---|---|---|
| **ACTIVITIES**<br>**General Activities**<br>1 General management.<br>2 Available information.<br>**Activities under Objective I (Generation of monthly time series of riverflow)**<br>1 Time Series Data Collection.<br>2 Measurement Data.<br>3 Time Series Data Processing.<br>4 Spatial Data Collection.<br>5 Spatial Data Processing.<br>6 Selection of rainfall-runoff model and modelling software.<br>7 Rainfall-runoff model calibration and validation.<br>8 Naturalisation of the observed riverflows.in calibration catchments.<br>9 Regionalisation of rainfall-runoff model parameters.<br>10 Generation of regionalised long-term rainfall time series.<br>11 Simulation of riverflows for all | **RESOURCES BY ACTIVITY**<br>Study-wide team \$3,80m<br>Basin-wide teams \$6.00m<br>Country teams \$4,77 m<br>Workshops \$1,70m<br><br>Total \$16,27 m | | |

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| catchments.<br>**Activities under Objective II (To develop and distribute databases)**<br>1 Database design for both time series and spatial data.<br>2 Populating the databases.<br>3 Identification of associated products.**Activities under Objective III (To develop and distribute tools)**<br>1 Development of application tools.<br>**Activities under Objective IV (To build capacity)**<br>1 Training and capacity building during the long term study.<br>2 Training and capacity building on products.<br>**Activities under Objective V (To improve networking)**<br>Networking. | | | |