The decline of hydrological data collection for development of integrated water resource management tools in Southern Africa

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Abstract The Commission for Africa report (2005) recommends a doubling of arable land under irrigation by 2015, and the World Bank water resources strategy (2004) calls for increased investment in water infrastructure in Africa. The NEPAD environment initiative (2003) states that addressing environmental issues is necessary for achieving goals of sustainable growth and development and a lasting solution to the eradication of poverty. Water resource management is clearly recognized as critical to economic development in Africa, but the value of the data on which decisions are based is less well appreciated, with a decline in data collection and management in recent years. The paper reviews the achievements of two regional initiatives to address the "data problem" and discusses how to use the experience gained for the benefit of future projects.

Key words Southern Africa; data collection; integrated water resource management; FRIEND; SADC-HYCOS

INTRODUCTION

The Southern Africa region experiences great spatial and temporal variations in climate. Lack of storage means water availability is determined primarily by precipitation, which varies annually between about 25 and 2000 mm. The rains are seasonal in nature, extremely variable and uncertain, and evaporation losses are generally high. Drought is a frequent event, as the regional droughts in 1991–1992, and 1994–1995 demonstrate. Flooding can have just as devastating an effect, as shown by the February/March 2000 disaster in Mozambique. There are few areas where there is water of assured quantity and quality throughout the year and, as populations increase, demands for water for irrigation, hydropower, and domestic and industrial supply are growing rapidly. At the same time, there is increasing emphasis on the maintenance of aquatic ecosystems and habitats through environmental flows. Water resource planning is further complicated by the large number of international river basins (e.g. the Okavango, the Zambezi).

The challenge for sustained economic growth and poverty alleviation to meet the Millenium Development Goals (MDGs) in the Southern Africa region is closely associated with sustainable use of natural resources and better management of the environment. Forecasts of the predicted impacts of climate change, in particular the more frequent occurrences of droughts, emphasize the need for a cooperative approach to water resource management across the region. Countries need to develop and implement long-term national programmes based on a multi-sectoral approach to water resources management to improve human welfare, ensure more efficient use of scarce water resources, maintain water quality, and provide options for future use.

THE STATUS OF HYDROMETRIC SERVICES

Within the Southern Africa region, there is a recognized lack of institutional capacity to monitor, plan and manage water resources effectively and sustainably. Many governments have only a limited ability to collect the data needed for long-term water resources management, particularly good quality hydrometeorological time series, such as rainfall and river flow. Long flow records are necessary to obtain reasonable estimates of flow statistics and their variability. In general, the higher the inter-annual variability in rainfall and river flow, the more important long record lengths become (Sene & Farquharson, 1998). At best, short periods of observation of water levels and flows provide only a glimpse of the true, long-term behaviour of a river and, at worst, can be misleading. Furthermore, there are several factors, both natural (e.g. climatic variability) and artificial (e.g. land-use change), that influence flow regimes over time.

However, in sub-Saharan Africa, and elsewhere, there has also been a marked decline in hydrometeorological data collection and management in recent years (e.g. World Bank, 1993;

WMO, 1996; Giles, 2005). This has been seen in the neglect and abandonment of stations, reductions in budgets for field maintenance and inspection, and insufficient discharge measurements being made to adequately define rating curves. Consequences include a lack of real-time data for monitoring the progress of droughts and floods, and insufficient long-term data for the design of water-related schemes and for the integrated management of large multinational river basins.

In addition, many governments have few skilled people and a high turnover of qualified staff, and lack the funds, equipment and facilities to do the planning and analysis necessary to guide water resource management decisions. The number of technical specialists remains small because of unattractive salaries and poor career prospects. The development of in-house expertise has been further compromised by previous over-reliance on external technical assistance that has not given sufficient attention to developing indigenous capabilities or adapting to the constraints of local circumstances. Furthermore, since water management issues are constantly changing, there is a need for continual training to ensure that organizations have sufficient human resources and technical expertise to meet their operational responsibilities.

THE SOUTHERN AFRICA FRIEND PROJECT

Since 1991, the Southern Africa FRIEND project (SA FRIEND) has aimed to improve the assessment and management of regional water resources through applied research (UNESCO, 1997, 2004). SA FRIEND is coordinated by the University of Dar es Salaam, and implemented by the national hydrological agencies (NHAs) of 12 Southern African countries. The objectives of SA FRIEND include developing improved operational hydrological methods and tools, based on knowledge of flow regimes, and establishing them within the NHAs in the region. Effective tools assist NHAs and water resource managers to more fully appreciate the variability and complexity of the water resource situation, to make improved surface water assessments, and to study the impacts of changes in water demand and climate.

Improved tools for water resource assessment and management developed under the SA FRIEND Phase II (UNESCO, 2004) include the ARIDA (Assessment of Regional Impact of Drought in Africa) software which enhances the abilities of NHAs to analyse historic river flow droughts and to monitor ongoing droughts, and the LF2000-SA (LowFlows-2000-Southern Africa) software which enables water resource managers to estimate flow characteristics and account for artificial influences at ungauged locations. The development of the analytical methods underlying these tools relies on the ready availability of the necessary data. Between 1992 and 1997, SA FRIEND Phase I (UNESCO, 1997) developed the first regional database of flow data from 676 stations across the region (Table 1). The period of record ranges from 1940 to 1992, and from 1 to 51 years per station, with an average of 23 years per station.

Table 1 Number of gauging stations and station years of flow data contributed to the SA FRIEND river flow database in 1997 by partner countries.

Country	No. of gauging stations	No. of station years
Angola	19	107
Botswana	24	371
Lesotho	23	222
Malawi	37	783
Mauritius	not a member in Phase I	
Mozambique	16	384
Namibia	46	847
South Africa	287	7828
Swaziland	35	632
Tanzania	79	1447
Zambia	25	600
Zimbabwe	85	1696
Total	676	15190

The intention was that future research projects could utilize these data, but both the ARIDA and LF2000-SA projects subsequently experienced some difficulties in this regard. The ARIDA project considered just 15 of the stations suitable for development of the drought analysis methods, and the LF2000-SA project obtained data instead directly from the NHAs. Problems with the database included: insufficient coverage of the range of basin areas, geomorphological conditions, climates and flow regimes; poor geographical spread, especially in the more arid areas; lack of information about artificial influences affecting flow regimes; and lack of long, validated records of good quality. Furthermore, the database was by then at least 10 years out of date and there was no provision for updates and maintenance during Phase II and beyond.

THE SADC-HYCOS PROJECT

During the period from 1998 to 2001, a network of 48 data collection platforms (DCPs) was established at key locations on the major rivers in the region (excluding South Africa which already had 46 established sites) under Southern African Development Community–Hydrological Cycle Observation System (SADC-HYCOS; Table 2). This EU-funded project was the second regional component of the World Hydrological Cycle Observation System (WHYCOS) of WMO, and the first attempt to implement a project of such technical complexity and magnitude in the Southern Africa region. Rodda *et al.* (1993) give a more detailed introduction to WHYCOS, and Houghton-Carr *et al.* (2000) provide further information on the aims and activities of SADC-HYCOS. Data are transmitted from each DCP on a 3-hourly basis using the METEOSAT satellite system, and stored in a regional database in the Department of Water Affairs in Pretoria.

Early in 2006, a review was undertaken to assess the current operational status of the 48 installed DCPs. Although a rather crude indicator of the long-term success, or otherwise, of the project, this is a readily available and quantifiable measure. Contact with eight out of the ten NHAs revealed that only seven out of the 38 DCPs installed in those countries were still operational (Table 2). Five of these are in Tanzania; Namibia also has five working DCPs, but has actually replaced and reinstalled all the original DCPs at its own expense. However, it was not possible to access data for the operational stations through the SADC-HYCOS website (http://sadchycos.dwaf.gov.za). Problems reported by the NHAs, some of which should have been foreseen, include: broken water level sensors, vandalism, wildlife damage (chewing cables), theft of solar panels, batteries and cables, electrical faults, transmission faults, flood damage, breakdown, and need for general maintenance and lack of resources to carry it out.

Table 2 Number of SADC-HYCOS DCPS, originally installed (1998-2001) and operational in February 2006.

Country	No. of DCPs installed	No. of DCPs operational
Angola	5	N/A
Botswana	4	1
Lesotho	5	N/A
Malawi	6	0
Mozambique	3	1
Namibia	5	0*
Swaziland	4	0
Tanzania	5	5
Zambia	6	0
Zimbabwe	5	0
Total	48	7

* Namibia has five operational DCPs which are replacements of their HYCOS DCPs.

DISCUSSION

The particular problems of data collection, and investment in data collection, in Southern Africa, and other developing countries, have been addressed to some extent by regional initiatives such as SA FRIEND and SADC-HYCOS. Through regular opportunities for communication and face-to-face interaction with counterparts from other countries in the region, both projects were successful in promoting cooperation between water resources managers and researchers, and the free exchange of data, information, expertise and ideas. All the countries regarded this as highly beneficial, and several of these contacts, usually between neighbouring countries, have continued.

However, a recent review of the SA FRIEND countries revealed disappointingly little use of the tools produced in Phase II, given that these were identified as priorities by the NHAs on the project steering committee. Furthermore, there has been little, if indeed any, communication between the coordination centre and the NHAs since Phase II finished and the last steering committee meeting in February 2004: regional communications have not been maintained. SA FRIEND was very much driven by funding from the UK Department for International Development (DFID), and when DFID-funding ceased, SA FRIEND activities ceased. There appears to be little drive within the Southern Africa region itself to sustain SA FRIEND and take it forwards, not because the project is of little relevance, but for reasons of personnel and resources.

Similarly, SADC-HYCOS was seen by several of the NHAs as yet another donor-driven activity using inappropriate equipment, tools and software and requiring inputs from already over-stretched hydrometric staff. The failure of some DCPs is not unexpected, but the failure of the majority is a cause of concern; many NHAs did not budget for maintenance as they had committed to do. Comments from the NHAs have referred to: poor project planning and implementation, lack of input from the NHAs, poor design and installation of the DCPs, inappropriate sensors for the climate and environment, no direct contact with the DCP supplier, inadequate training of local staff, and late implementation of the website which has experienced repeated malfunctioning.

Looking to the future, the extension of the WR90 water resources modelling system, started in SA FRIEND Phase II, provides an opportunity for assessing water resources availability at ungauged locations across the whole of Southern Africa using an approach based on the Pitman rainfall–runoff model (UNESCO, 2004). The Netherlands government has recently finalized an agreement with SADC for financial support to SADC-HYCOS Phase 2, a first step of which would involve re-establishing contact with the NHAs and rehabilitating the existing DCPs. If initiatives like SA FRIEND and SADC-HYCOS are to be successful in subsequent phases, it is imperative that the issues relating to their long-term lack of achievement to date are resolved.

THE WAY FORWARD

It is important that water resources are developed in an equitable, integrated and sustainable manner, and in such a way as to support enhanced socio-economic development. However, hydrological systems are complex with many uncertainties. It is essential that methods and tools such as those developed in SA FRIEND are based on consistent, good quality, and readily available data from sites of key importance throughout the region and representing the full range of probable flow conditions. The Commission for Africa (2005) recommends improved capture and storage of existing data, new monitoring stations in low coverage areas, and the uptake and use of data by African institutions. A regularly updated regional database of such records, whether sourced from existing manually-read gauges or new automatic DCPs, or from a combination of the two, would be an invaluable data set for many hydrologists wishing to solve practical water resource problems. Whilst the data might not be ideal for every application, they would at least provide a starting point for initial assessments, particularly to support investments into major water resource projects e.g. irrigation schemes, and a foundation from which to respond to new challenges.

In recognition of the need for African researchers to become more involved in the design and planning of projects, African Water is a current EU initiative to increase the involvement of Africans in the water-related research programmes of the EU (http://www.africanwater.net). There is no lack of research ideas within SADC NHAs; identified topics include: sedimentation issues, water balances of lakes, impacts of climate change, water use efficiency in irrigation, flood prediction and warning, transmission losses, environmental flows, transboundary water issues, and future data collection strategies. African Water will give African hydrologists, water resource managers and researchers, including those in SA FRIEND NHAs, the capability and opportunity to actively participate in EU-funded research, either through collaboration with European researchers, or through their own proposals.

There is also a need for better communication and coordination of the water-related research activities of donor development agencies, and recognition by the donors that sustaining an established and successful programme (which covers many data-related projects) can be as beneficial as, and possibly more valuable than, support to a comparatively exciting, but untested, new initiative. Donors also need to envisage a longer time horizon (10–15 years) for project funding than the 3–5 years typical now. The EUWI-ERA-NET is an EU scheme to provide a framework through which member states can work together more effectively (http://www.euwi-era.net). The ERA-NET aims to work with developing country partners to develop a strategy and work plan to identify their priorities for water-related research and potential collaboration, and to establish tools for more efficient sharing of information on member state research programmes.

Finally, whilst both the SA FRIEND and SADC-HYCOS projects did involve significant capacity building components, they perhaps relied too heavily on key individuals trained in regional workshops who did not necessarily pass on their knowledge to their colleagues, with the result that when some of these staff left the NHAs (often for better paid jobs in the private sector), the capacity was lost. Therefore, capacity building requirements will feed into the design of future systems and tools, and future capacity building activities will place greater emphasis on the dissemination of training to ensure maximum potential impact in terms of numbers of people reached.

CONCLUDING REMARKS

Water resource management is clearly recognized as critical to economic development, unlike the value of the data on which crucial decisions are made. Institutional reform is needed to acknowledge the importance of hydrometry and data management within, and by, the NHAs. A more coherent approach to data collection requires local capacity, appropriate technology, and long-term donor and institutional commitment, combined with the more intimate involvement of pro-active African water engineers and researchers from the initial concept stage of new projects. The implementation of SA FRIEND and SADC-HYCOS was costly in terms of both effort expended and resources used, and it is essential that the valuable experience gained and lessons learned are not forgotten, and are used to inform future proposals and investments into water resource schemes.

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