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MANAGEMENT, CONSERVATION AND RESEARCH OF INTERNATIONALLY SHARED WATERCOURSES IN SOUTHERN AFRICA – NAMIBIAN EXPERIENCE WITH THE OKAVANGO RIVER AND RIVERS OF THE EASTERN CAPRIVI

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Summary

Although the emphasis of the recent National Rivers Research Initiative (now the Research Programme for the Management of Rivers) in South Africa was on river research in that country, the reality is that in southern Africa many watercourses are shared by more than one country. Therefore a central issue in integrated river basin management and development should be the recognition of the principle of international joint planning, conservation, monitoring and research.

Co-operation and a better understanding of shared waters would prevent deleterious impacts, not only in the country where they occur, but also in those downstream. With this in mind, since the early 1980s Namibia has worked on joint cross-border projects in efforts to manage and conserve her shared water bodies. These include joint river gauging exercises, biological control of *Salvinia molesta* in the eastern Caprivi region and, more recently, the application of a biological monitoring technique, the South African Scoring System version 4, to north-eastern perennial rivers.

The formation of the Joint Permanent Water Commission between Botswana and Namibia enabled the Departments of Water Affairs of both countries to work together on their shared rivers. The establishment of the Permanent Okavango River Basin Water Commission between Angola, Botswana and Namibia in 1994 improved this co-operation even further. Namibia and its counterparts are thus committed to sharing information, co-ordinating research and monitoring activities and to undertaking detailed studies to improve their knowledge of these shared systems.

Such cross-border co-operation is vital for the survival of shared river systems not only as ecological entities in their own right, but also as sources of water, power and the other resources they provide, both directly and indirectly, to the human and wildlife populations that they support.

Introduction

Long before southern African countries pledged co-operative and sustainable management of shared rivers by the signing of the Southern African Development Community (SADC) Water Protocol in August 1995, Namibia was engaged in cross-border co-operation to ensure a joint approach to river management and monitoring. This arose from a need to understand river systems as a whole and to assess what comprised a "reasonable and equitable share" for each basin state, as required in terms of the Helsinki Rules 1966. The Law of Non-Navigational Uses of International Water Courses 1994, stipulates an obligation "not to cause harm" to neighbouring riparian countries.

Initially this co-operation was facilitated through the Southern African Regional Commission for the Conservation and

Utilisation of the Soil (SARCCUS). This agency was formed in Pretoria in 1950 essentially to promote closer technical co-operation between member states on agricultural matters, including hydrology and to some extent the use and control of natural resources. Active member countries included Botswana, Lesotho, Malawi, Namibia, South Africa, Swaziland and Mozambique. The Department of Water Affairs (DWA) in Namibia participated actively in the Standing Committee for Hydrology and its sub-committee for aquatic weeds (de Wet 1991). This co-operation fostered a good working relationship between DWA technical staff in Namibia and Botswana. It allowed the exchange of information and, from time to time, somewhat clandestine visits to gauging stations and project sites on the Okavango as well as the Kwando/Linyanti/Chobe river systems. Most of the pre-independence technical co-operation with Botswana on shared rivers was through contacts established at SARRCUS meetings and focussed mainly on hydrological monitoring and aquatic weed control.

After Independence in 1991, this co-operation was formalised through the establishment of a Joint Permanent Water Commission (JPWC) between Namibia and Botswana. At the first meeting, on 18 November 1991 in Gaborone, a preliminary draft proposal for a basin-wide, multi-disciplinary environmental assessment of the Okavango River basin was submitted for discussion and a technical subcommittee was formed to guide the investigations. A similar body, the Permanent Joint Technical Commission (PJTC), had been established between Angola and Namibia a year previously to deal with the Kunene River. Independently, both commissions discussed the need to establish an Okavango River Basin Commission involving all three countries. The first step in this process was realised when an Angolan delegation, headed by the Director of the State Secretariat of Energy and Water, attended the second JPWC meeting, held in Windhoek on 25 June 1992. Discussion focussed on the proposed tripartite water commission between Angola, Botswana and Namibia and each delegation agreed to put the proposal to their respective governments. The intention was to have the final documents available for signature by the Heads of State at the JPWC meeting in Mbabane, Swaziland, on 22 August 1992. Unfortunately, due to unforeseen circumstances, the agreement to establish a Permanent Okavango River Basin Water Commission (OKACOM) was not signed until 15 September 1994. More recently, a Commission to facilitate co-operation between Botswana and Namibia on a much wider range of activities was inaugurated in Gaborone, Botswana. The agreement to establish this Joint Permanent Commission of Co-operation (JPCC) was signed in Windhoek on 26 July 1990 by the two heads of State and became effective when the first session was held nine years later. This Commission is responsible for the identification of co-operative programmes beneficial to both countries as well as for studies to facilitate this co-operation, particularly in the fields of agriculture, water, tourism, wildlife, industry, trade, mining, energy, health, education, transport and communication.

Within SADC there are some 15 other commissions and committees on shared rivers (Pallett, 1997). Besides the OKACOM, JPWC, JPCC and the PJTC, Namibia is party to the Permanent Water Commission with South Africa on the Orange River established in September 1992 and another treaty on the Vioolsdrift and Noordoewer Joint Irrigation Schemes signed at the same time. Namibia has also been involved in the Zambezi Action Plan (ZACPLAN) which was initiated in 1985.

Discussion

A number of examples of international co-operation on shared perennial rivers in north-eastern Namibia serve to illustrate the different levels at which work was required to establish and ensure trust and then to carry out specific studies and fieldwork. This sort of co-operation has helped to promote the integrated management, conservation and research of these shared river systems. Namibian experience in this field includes the commissioning of joint studies, aquatic weed control, hydrological monitoring and the collection and identification of invertebrates for water quality assessments. The agencies involved ranged from individuals and communities, through private companies, NGOs and government departments, to international water commissions.

Co-operation between scientists in Namibia and Botswana was first established on a one-to-one technical level through conference links and meetings. This co-operation remained fairly informal until Namibia became independent because the political situation at the time precluded more formal links. The co-operation was driven by the enthusiasm of individuals who realised the need to jointly manage shared resources.

The Permanent Okavango River Basin Water Commission (OKACOM)

OKACOM was initiated by scientists, engineers and technicians working within the Okavango basin (Figure 1) who realised that co-operation and sharing of information was essential to the holistic management of a river system shared by different countries. Although co-operation existed at the technical level between scientists and engineers from both Namibia and Botswana it was considered important to formalise this at the political level, particularly once Namibia had gained its independence, so as to facilitate the involvement of Angola. Because the initiative came from the technical level there was no difficulty in facilitating collaboration between scientists and engineers. All three member countries had relatively small scientific communities, with most of the scientists and engineers working on the Okavango Basin being known to one another and being based in either the relevant water or environment ministries. Thus it was not difficult to identify individuals in member countries to serve on the Okavango Basin Steering Committee, which is the technical committee of OKACOM.

Once OKACOM was officially formed in September 1994 the member countries wasted little time. Each country appointed three commissioners, each of whom represented either the water or environment sectors and who held ranks of Director or higher in their respective civil services. OKACOM was given high political status, with all commissioners appointed by their respective cabinets.

The first task recognised by OKACOM was that a better mutual understanding of the Okavango River basin was essential to future management, conservation and utilisation of the Okavango River and the natural resources within it. Thus, even before the first OKACOM meeting, a detailed project proposal for an environmental assessment and integrated management plan of the Okavango basin was drafted and circulated to all three countries for comment. Nominations were also sought for the more technical Okavango Basin Steering Committee (OBSC).

At the first meeting of OKACOM, held in Windhoek in June 1995, the project proposal for the environmental assessment was approved and OBSC members were officially appointed and given the task of finding funds to conduct the basin-wide project. A funding proposal was drafted at their first meeting on 4 July 1995 with the intention of securing funds from the Global Environment Facility (GEF). At the second OKACOM meeting, held in Botswana on 1 August 1995, the funding proposal was finalised and approved

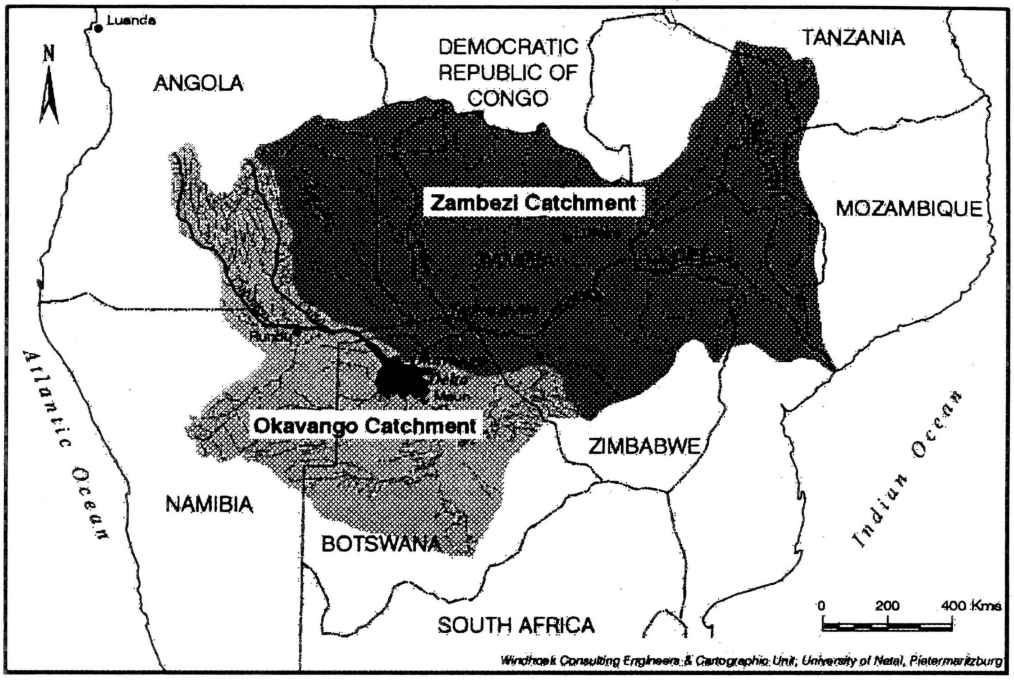

Figure 1. Map of the Okavango and Zambezi river basins.

for submission. It was submitted on 17 August but was unsuccessful and so was redrafted and resubmitted on 25 October 1995. Unfortunately the submission again proved unsuccessful and, early in 1996, GEF recommended that OKACOM undertake a GEF-funded preparatory project to enable the three countries to prepare a more appropriate brief for GEF assistance. Funds for the preparatory work were made available in March 1997 and in June 1997 a project manager was appointed. The first task of the preparatory study was to establish a consultative process involving a variety of stakeholders including the people dependent on the river and its resources for their day-to-day needs. This was done through a series of meetings with communities alongside the river in both Namibia and Botswana. Unfortunately it was not possible to hold similar meetings in Angola. The meetings served to explain what OKACOM was and that seventeen specialist studies had been commissioned to assess the current status of information, research, conservation and resource utilisation in all three countries better. These studies involved some 20 scientists already active in the three Okavango basin countries.

The results of these specialist studies, as well as information from the available literature and from satellite imagery, have now been used to prepare a trans-boundary diagnostic analysis of the Okavango River basin. Based on the findings of the analysis, a strategic action programme (SAP) framework is being drawn up for the tasks ahead but this will only be finalised once funds are made available for the detailed environmental assessment project. The first stage of the project is to consult with stakeholders and donors and to plan a series

of projects within the SAP. Some of the projects with evident regional or global benefits will be funded by GEF whilst others will be funded by the countries themselves, or by interested donors.

At an OKACOM meeting held in Gaborone on 29 May 1998, the revised request to the GEF was provisionally approved for submission on 11 August 1998. It was agreed that further work needed to be done to finalise the trans-boundary diagnostic analysis report and the GEF brief. The study manager was given the responsibility of dealing with this within the deadlines set by the GEF. OKACOM met again in May 1999 in Maun to endorse the proposal for GEF funding before submitting it to the GEF Council.

OKACOM work to date has shown that the expertise to manage and conduct this type of project is available within the southern African member countries and that, with co-operation and respect, it is possible to negotiate an agreed and mutually beneficial approach to shared river resources. The proof will lie in how well OKACOM copes with the challenge of the environmental assessment and integrated management plan, should the funding become available.

This example of co-operation between three countries, with the aim of understanding and managing an internationally shared river basin better, illustrates the value of communication at several different levels. Discussions ranged from those at a very high level, for example between Presidents, through formal meetings of the international water commission, to technical co-operation between individual members of the OBSC. Communication included interaction between the study manager, scientists and NGOs from each of the three countries, as well as between the project team, tribal authorities and villagers living in the river basin. Experience proved that better work can be done when the local community is involved, that consultation is vital and that this approach often results in a more meaningful outcome. Consultation with local communities was facilitated by working closely with NGOs active in the basin. During the preparatory study the study manager personally approached the different NGOs active in the area and solicited their assistance. This worked well as these organisations were known and had trusted contacts with the communities in the Okavango basin. A recent positive development in this respect has been that the Desert Research Foundation of Namibia has now joined the Okavango liaison group, comprising a group of NGOs and interested parties, formed in Botswana in 1996.

The feasibility study on the Okavango River – Grootfontein link of the Eastern National Water Carrier

Following two seasons of poor runoff (1994/95 and 1995/96) and the resultant low water levels in the state impoundments supplying the central area of Namibia, including the city of Windhoek, it became evident that a water crisis was looming. After consultations between the ministers responsible for water in Namibia, Angola and Botswana, the Ministry of Agriculture, Water and Rural Development in Namibia commissioned a contingency feasibility study to expedite the proposed linking of the Eastern National Water Carrier to the Okavango River if necessary. The initial environmental evaluation (IEE) carried out was a contingency study in that it was not a fully comprehensive environmental impact assessment (EIA), which was due to the emergency nature of the water crisis. Although not a full EIA, the IEE included an assessment of the impacts of the scheme both along the proposed pipeline route and on the Okavango River and delta downstream of the proposed abstraction site at Rundu.

This assessment, funded solely by Namibia, included an evaluation of impacts in neighbouring countries. The downstream assessment covered the area from a point

40km upstream of Rundu to the distal end of the Okavango delta. It included the river and riparian zone on both sides of the river as well as part (1km) of the terrestrial zone bordering the river in Angola, Namibia and Botswana (Water Transfer Consultants, 1997). Fortunately, improved runoff in 1996/97 averted the immediate water supply crisis without the need to proceed with constructing an emergency pipeline.

Given the limited time available for the study, a fairly in-depth initial environmental evaluation was produced. This will be a valuable contribution to a more detailed EIA when required. The proposed project generated a great deal of publicity and it highlighted the importance of consultation with neighbouring countries, not only at government level but also at technical, NGO and community levels.

Despite a series of meetings with affected communities, researchers experienced animosity and a lack of co-operation in the collection of historical or oral information. In retrospect this may have been due to the time constraints caused by the urgency of the situation – people had been caught unawares and were already anxious because of the poor rains. This experience proved the importance not only of securing community involvement but also of how and when it should be sought. The pipeline feasibility study was not an OKACOM project but was an emergency study conducted by the Namibian Government during a serious drought situation. In retrospect, the study would have profited by closer collaboration with OKACOM. The information that will be provided by the 'Environmental assessment and integrated management plan of the Okavango Basin' proposed by OKACOM will, in future, prepare the ground for subsequent environmental impact assessments and will help to avoid the pitfalls experienced during the pipeline feasibility study.

Control of Salvinia molesta *in the eastern Caprivi*

The South American floating water-fern (*Salvinia molesta*) was first recorded in the Zambezi River in 1948 (Mitchell, 1967), in Botswana by 1950 (Pfotenhauer, 1990) and in the eastern Caprivi wetlands in Namibia by 1965 (Edwards *et al*, 1972). Its uncontrolled growth resulted in large areas of open water being covered. This had an adverse effect on the ecology of the native fauna and flora on both sides of the border between the 1960s and early 1980s. Infestations occurred along the international borders in the Kwando/Linyanti/Chobe system (Figure 1) where large mats, some up to 0.5m thick (Bethune, 1996), completely covered the water surface. The weed was also a problem within the borders of each country, for example in much of the eastern Caprivi in Namibia (Seaman *et al*, 1978; Schlettwein and Bethune, 1992) and in the Moremi Wildlife Reserve in the Okovango Delta (Pfotenhauer 1990, Forno and Smith 1999). Both countries' first uncoordinated attempts at controlling the weed involved the use of chemicals when the weed was sprayed with various types of herbicide. As early as 1975 a joint South African/Botswanan control programme was initiated in an attempt to eradicate the weed using herbicides, mechanical removal and biological control (Edwards and Thomas, 1977). These efforts proved expensive and ineffective and were later discontinued.

Salvinia molesta had also caused similar problems in many other parts of the world, including Australia (Room *et al*, 1981). Researchers there identified a potential control agent in the form of a small curculionid beetle (*Cyrtobagous salviniae*), native to the same part of South America as the weed itself and whose life cycle was entirely dependent on it. They found that the adult beetles fed on the apical growing shoots,

that the larvae burrowed within the stems of the plant and that the eggs were laid in the pseudo-root structure, where the pupae then developed. Trials were carried out to ensure the host specificity of the beetle and it was then released. This programme successfully reduced the quantity and controlled the further spread of the weed (Thomas and Room, 1986). In 1983 the DWA in Namibia released the same beetle species in the Caprivi and within 15 months the first success was recorded at Ngoma Bridge (DWA, 1985; Schlettwein and Bethune, 1992). The DWA in Namibia demonstrated the success of the new control agent to their counterparts in Botswana, who obtained and released beetles in 1985. As a separate part of the measures used to control the weed, legislation was passed in Botswana in 1986 strictly regulating the importation and movement of boats and fishing equipment. To help with these measures, Namibia also introduced boat control regulations at border checkpoints in the Caprivi and Okavango regions, including the spraying of equipment with herbicides. Information packages, including pamphlets and posters, were produced and distributed in both countries as part of an intensive education programme to reduce the spread and effects of *S. molesta* and any other potentially harmful aquatic weeds (Bethune, 1996).

In 1992, Botswana asked Namibia to verify reports of water hyacinth (*Eichhornia crassipes*) occurring in the Chobe River. A Namibian team surveyed the area and fortunately found no evidence of the weed. Since that time, Namibia and Botswana have undertaken joint annual weed surveys in the Chobe.

Namibia now believes *S. molesta* to be a permanent feature of its wetland ecosystem ecology and currently to be at an acceptable level of infestation (Taylor, 1997). Levels of infestation in Botswana are also low but that government maintains a total eradication policy, particularly in the Okavango delta area. Despite these different approaches, the DWAs of both countries have been working side by side on the control of aquatic weeds since the 1970s. This has been accomplished by the regular exchange of information, in the form of data and reports, and of ideas gleaned from meetings and discussions. Regular, and mostly informal, meetings between the researchers directly involved with weed control in each country, as well as joint field surveys of problem areas in either country, were the main methods by which this information exchange was accomplished. Transmission of data, meetings and joint surveys were all approved at a Departmental or Ministerial level but where carried out at scientist level. This continues to the present day, with the two joint surveys carried out to assess the quantity and health of weed in the Chobe River after the major flooding in 1998 being the most recent examples of this ongoing co-operation.

One of the shortcomings of the biological control programme in Namibia has been the lack of involvement of local communities. If people living in the affected areas had been made aware of and included in the work to control the weed they could have assisted in monitoring and alleviating infestations. The DWA in Namibia are now addressing this issue and have made contact with relevant tribal authorities in the eastern Caprivi.

Hydrological monitoring

Namibia has been carrying out hydrological surveys in the Okavango and eastern Caprivi rivers since the early 1980s, with these data being used both to warn local people of the possibilities of flooding and to provide a long-term hydrograph. Information about what is happening further upstream in the Zambezi basin has also been provided to Namibia by Zambia for some time. This ensures early warning of the size, timing and duration of any floods. In 1992 the Canadian International Development Agency (CIDA) donated funding for the establishment of a

comprehensive telemetry network to provide real time hydrological data (such as rainfall and water levels) for flood warnings and operation of the hydro-power plants in the Zambezi basin. All participating countries were asked to provide some top-up funds to ensure sustainability of the project and to provide information to a central co-ordinating body, the Zambezi River Authority (ZRA). The DWA in Namibia has honoured its duties in this respect and regularly provides data to, and receives data from, the ZRA.

In 1991, teams from the Hydrology Divisions of both Namibian and Botswanan DWAs ran joint river gauging exercises in all the rivers of the eastern Caprivi area. These were done to ensure that the same hydrological parameters were being assessed both sides of the border and to rationalise fieldwork and the gauging network. This rationalisation was designed to reduce the waste of effort through monitoring duplication and to divert it more towards expansion and improvement of the combined network. This first joint operation highlighted the co-operation required in future and identified how best to achieve this, as for example through twice yearly joint surveys (Crerar, 1992). Such ideas and decisions would never have arisen without the initial cross-border collaboration. The results of this first joint survey were submitted to the JPWC for consideration and were approved at the regional level (JPWC, 1992).

Use of SASS4 for biological monitoring of water quality

With population growth in Namibia, Botswana and Zambia, coupled with potential peace in Angola, further demands are likely to be made on the Zambezi, Kwando and Okavango river systems. The effects of these changes are bound to impact on water quality in the rivers and on their floodplains. Monitoring of these changes, as well as timeous pollution detection within these systems, will be made easier if information provided by regular, routine sampling is ready at hand. Regular invertebrate sampling as a method of assessing changes in water quality is well established in Europe (particularly in the UK) and now in South Africa. Such sampling is useful to detect changes caused directly, as a consequence of chemical or biological pollution, or indirectly, as a consequence of physical perturbations such as water abstraction or the effects of dams. The information gained from such research is very valuable, particularly in relation to shared watercourses. It can be used to assess changes as and when they happen and to help elucidate why and where changes are occurring, regardless of whether they originate within or beyond a country's borders. Such information can also help determine ways in which the observed effects might be ameliorated.

An empirical biotic index to measure the quality of water in South African streams and rivers was devised by Chutter (1972); this was based on, and is similar to, the Biological Monitoring Working Party (Chesters, 1980; National Water council, 1981; Armitage *et al*, 1983) system used in the UK. After much refinement (Chutter, 1992; Chutter & Geuppert, 1993; Chutter, 1994a; Chutter, 1994b; Chutter, 1998) this index, now known as the Southern African Scoring System version 4 (SASS4), has been established in South Africa where it has undergone extensive testing and has now been implemented.

At the request of DWA Namibia, Dr. Chutter made a visit to the Caprivi region in February 1997 to assess the applicability of this index in the perennial rivers of the north-east. Several recommendations were made, including the need for the modification of the standard South African macroinvertebrate checklist to reflect the Namibian fauna, that scores for invertebrates unique to Namibia needed to be allocated and that a baseline survey should be conducted to establish the pattern of seasonal change in

macroinvertebrate fauna (Chutter, 1997; Taylor, 1997).

A one-year baseline survey has now been completed and information gathered. Once this information has been collated, DWA Namibia will again be referring to scientists working in the National River Health Programme in South Africa (a national programme to assess and monitor water quality standards and future changes countrywide). We will be seeking critical appraisal of the work we have done and will require specific help with the allocation of scores to previously unrecorded taxa. Other improvements to the techniques and suggestions conducive to successful implementation of a regular monitoring system will also be sought. It is hoped that once completed, routine biological monitoring will be initiated in all Namibia's northern perennial rivers in order to establish a better understanding of these systems before further significant changes occur.

DWA Botswana, hearing of this work via the *Salvinia* scientists, then also expressed an interest in starting and/or collaborating in this type of work. In response to requests from them, DWA Namibia made available copies of all their invertebrate keys, papers on the development of SASS and on SASS methods and agreed to train staff in sampling, sorting, identification and data analysis techniques as and when necessary. In return, DWA Botswana wrote a letter supporting a funding proposal to the United States Agency for International Development (USAID), written by Namibian scientists to establish a national monitoring programme in Namibia. One of the main thrusts of the funding proposal, in order for it to receive funding, was that all data collected from international waters would be made available to the appropriate neighbouring country as part of the project. As a consequence of this, the funding proposal then also received support from sources in South Africa and Zimbabwe. This was achieved through the personal contacts made by the scientist who wrote the funding proposal, many of which had been brokered during conferences (e.g. Southern African Society of Aquatic Scientists), meetings (e.g. re: *Salvinia*) and joint surveys (e.g. the Rundu – Grootfontein pipeline IEE). Scientists in Botswana, Namibia and South Africa now wish to see how this method can best be implemented and the results used to monitor, protect and manage their shared waters.

Conclusion

For a National Rivers Research Initiative to be effective and to work in southern Africa it must take into account international obligations and environmental responsibilities, particularly when working with cross-boundary resources such as watercourse systems. The rivers of north-eastern Namibia provide a good example. The management, conservation and research of internationally shared river basins can only be effective if done in a co-operative way. This co-operation must take into account not only past work but also local knowledge and current studies, whether located inside or outside the country of origin. Co-operation also needs to be carried out at many different levels ranging from community involvement through joint technical committees of government to personal interaction between scientists, such as is seen at Southern African Society for Aquatic Scientists meetings. Initial contact to commence or co-ordinate joint research efforts may often have to be approved at a managerial or political level. Once this has been done it is best to "personalise" the contact as soon as possible because attempting to work at this high level can often be a prolonged process. Experience has shown that establishing a rapport with a specific person or small group of people in another country is the best way to forge a successful working relationship. Recent experience with the OKACOM preparatory study and the initial environmental evaluation done as part of Namibia's proposal to abstract

water from the Okavango River has also shown that contact with or through local people, or local structures such as tribal authorities or local government, is essential.

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References

ARMITAGE, P. D., D. MOSS, J. F. WRIGHT and M. T. FURSE (1983). The performance of a new biological water score system based on macroinvertebrates over a wide range of unpolluted running-water sites. Water Research 17: 333-347.

BETHUNE, S. (1996). Biological control of *Salvinia molesta* in the eastern Caprivi. Progress report: 1980 - 1995. Department of Water Affairs Report RR/96/1, 52pp.

CHESTERS, R. K. (1980). Biological Monitoring Working Party. The 1978 national water testing exercise. Department of the Environment (UK), Water Data Unit, technical memorandum 19: 1-37.

CHUTTER, F. M. (1972). An empirical biotic index of the quality of water in South African streams and rivers. Water Research 6: 19-30.

CHUTTER, F. M. (1992). Research on the rapid biological assessment of water quality impacts in streams and rivers. Progress Report 1992, Water Research Commission, Pretoria.

CHUTTER, F. M. (1994a). Research on the rapid biological assessment of water quality impacts in streams and rivers. Progress Report 1994, Water Research Commission, Pretoria.

CHUTTER, F. M. (1994b). The rapid biological assessment of stream and river water quality by means of macro invertebrate community in South Africa. *In* M. C. Uys (ed.) Classification of rivers, and environmental health indicators. Proceedings of a joint South African / Australian Workshop, February 7-14 1994, Cape Town, South Africa. Water Research Commission Report No. TT 63/94: 217-234.

CHUTTER, F. M. (1997). A report on the application of the SASS4 method for the assessment of river water quality to the Zambezi, Okavango and Kwando/Linyanti Rivers in northern Namibia. Afridev report to the Department of Water Affairs: 14pp.

CHUTTER, F. M. (1998). Research on the rapid biological assessment of water quality impacts in streams and rivers. Report to the Water Research Commission, WRC Report No. 422/1/98.

CHUTTER, F. M. and S. R. GEUPPERT (1993). Research on the rapid biological assessment of water quality impacts in streams and rivers. Progress Report 1993, Water Research Commission, Pretoria.

CRERAR, S. E. (1992). Combined Namibian / Botswanan Okavango gauging and Kwando/Linyanti/Chobe investigation, 15 – 21 October 1991. Unpublished report, Hydrology Division, DWA, Namibia.

DEPARTMENT OF WATER AFFAIRS (1985). Biological control of *Salvinia molesta* in the eastern Caprivi. Annual agricultural and industrial show pamphlet, Department of Water Affairs, Namibia.

DE WET, J. S. (1991) The control of floating water weeds in the SARCCUS region. Unpublished report to SARCCUS workshop on Aquatic Weeds, Harare, Zimbabwe, 24 – 27 June 1991.

EDWARDS, D., C. J. MUSIL, T. C. P. VAN ROBBROECK, W. VAN DER MERWE, W. F. WAUGH, O. H. BENNISON, N. S. URBAN, P. A. SMITH, P.H. WILSON and J. A. RAFFLE. (1972). Report on a joint Botswana – South Africa survey of the extent and degree of occurrence of *Salvinia molesta* (Kariba weed) in the Chobe-Linyanti-Kwando River system. Unpublished report to the Botswana and South Africa Governments.

EDWARDS, D. and P. A. THOMAS (1977). The *Salvinia molesta* problem in northern Botswana and eastern Caprivi area. *In*: Annecke, D. (ed.). Proceedings of the second national weed conference of South Africa, 4-7 February 1977, Stellenbosch. A.A. Balkema, Cape Town: 221-237.

FORNO, I. W. and P. A. SMITH (1999) Management of the alien weed *Salvinia*

molesta in the wetlands of the Okavango, Botswana. *In*: W. Streever (ed.) An international Perspective on Wetland rehabilitation: 159-166. Kluwer Academic Publishers, Netherlands

JOINT PERMANENT WATER COMMITTEE (1992). Hydrology of the Kwando/Linyanti/Chobe and Zambezi River systems; proposals on future joint Namibian/Botswanan co-operation. Unpublished submission to JPWC meeting of 25th June 1992.

MITCHELL, D. S. (1967). A survey of *Salvinia auriculata* in the Chobe River system, March 1967. Unpublished report to the Botswana Government, 12pp.

NATIONAL WATER COUNCIL (1981). River Quality: The 1980 survey and future outlook. National Water Council, London.

PALLETT, J. (1997) Sharing water in Southern Africa. Desert Research Foundation of Namibia, Windhoek, Namibia.

PFOTENHAUER, L. (1990). Aquatic weed control, Botswana. Pamphlet by Ministry of Mineral Resources and Water Affairs, Department of Water Affairs, Botswana.

ROOM, P. M., K. L. S. HARLEY, I. W. FORNO and D. P. A. SANDS (1981). Successful biological control of the floating weed *Salvinia molesta*. Nature. 294: 78-80.

SCHLETTWEIN, C. and S. BETHUNE (1992). Aquatic weeds and their management in southern Africa: Biological control of *Salvinia molesta* in the eastern Caprivi. *In* T. MATIZA and H.N. CHABWELA (eds.), Wetlands Conservation Conference for Southern Africa. Proceedings of the SADC Wetlands Conference: 173-187.

SEAMAN, M. T., W. D. SCOTT, R. D. WALMSLEY, B. C. W. VAN DER WAAL and D. F. TOERIEN (1978). A limnological investigation of Lake Liambezi, Caprivi. Journal of the Limnological Society of southern Africa. 4(2): 129-144.

TAYLOR, E. D. (1997). The status of *Salvinia molesta* infestation in the eastern Caprivi wetlands - 1996 report, update and recommendations. Department of Water Affairs report WE/97/1: 16pp.

THOMAS, P. A. and P. M. ROOM (1986). Taxonomy and control of *Salvinia molesta*. Nature 320: 581-584.

WATER TRANSFER CONSULTANTS (1997). Feasibility study on the Okavango River to Grootfontein Link of the Eastern National Water Carrier. Report to Department of Water Affairs, Namibia: 6 volumes.

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