Introduction: Opportunities and risks

Mikiyasu Nakayama

It is a known fact that, world wide, there are more than 200 international water systems and that some 60 per cent of the global population resides within such systems. This has important implications for international security of these water systems and the people dependent on them. With this in mind, the United Nations University (UNU), within the framework of the environmentally sustainable development initiatives, has carried out various activities related to such international water systems as the Aral and Caspian seas; and the Ganges, Jordan, Danube, La Plata, and Nile rivers (Nakayama and Jansky 2001).

This volume reflects the continuing efforts of the UNU in the field of international water systems. The shared river systems in Southern Africa are featured in this volume. The Southern African region is one of the ‘‘hottest’’ areas in terms of managing international water systems, because (a) there is a great disparity in the availability of water between the relatively ‘‘wet’’ northern part of the region and the ‘‘dry’’ southern part, (b) the first-ever transboundary transfer of water (between Lesotho and South Africa) has occurred within the region, (c) discussions have taken place in many international water systems about sharing of water resources among basin countries, and (d) some planned water-transfer schemes have been the subject of disputes, in both environmental and security contexts.

The author once worked on the Zambezi River system in the Southern African region towards establishment of a basin-wide management scheme for the shared water resources (David, Golubev, and Nakayama 1988). The region was then in a different political setting from that currently existing, and that political setting led to many difficulties in developing an action plan for managing the Zambezi River basin, as well as for its implementation (Nakayama 1999). Those difficulties have now been removed as a result of the current political setting and the ensuing friendly atmosphere in the entire region rather than the hostile relationship that existed between South Africa and other nations in the 1980s. This change may be interpreted as an opportunity for the region, in that all the countries in the region can participate in discussions about water matters on an equal footing; on the other hand, the new circumstances may be interpreted as a risk for the region, in that each country now has a ‘‘free hand’’; thus, a very protracted negotiation process may be necessary before any region-wide decision is achieved as a result of international discussion.

It is hoped that this volume, which deals with issues related to international water systems of Southern Africa, will help to reduce the risks involved in negotiations concerning international water systems. Chapters 1 to 5 are an overview of the region and of thematic issues. Specifically, Chapter 1 (by Heyns) serves as an introduction to the situation of shared water resources in the Southern African region, and amply reflects the extensive experience of the author in dealing with international water issues in that region. In chapter 2, Bruch depicts, from his great involvement in environmental issues in the African continent, how public participation and access to information are instrumental in managing international waters. Chapter 3 (by Giordano and Wolf) features the role of treaties among riparian states in their dealing with the shared water resources; this chapter is based on their long-term efforts in developing the Transboundary Freshwater Dispute Database (TFDD) and analysis with the database. Chapter 4 (by Nakayama, the editor of this volume) reflects his experience in the formulation and implementation phases of the Zambezi Action Plan (ZACPLAN); emphasis is placed on institutional aspects of international water management, with reference to other international water systems. Salewicz suggests, in chapter 5, how a decision support system (DSS) could be used as a viable planning tool for decision-makers. His remarks stem from his experience in developing a DSS for the Zambezi River basin, for optimization of reservoir management in the basin. These chapters provide readers with an overview of the region, as well as of efforts made and instruments developed for international water systems of the region for the purpose of more rational and streamlined management of these systems.

Chapters 6–10 are case studies on shared international water systems in the region. Chapter 6 (by Turton) vividly describes the rather complicated hydropolitics among countries of the Orange River basin. The fact that many water-transfer schemes are either planned or implemented in the basin makes it a most interesting and informative example among other international water systems. In chapter 7, Ashton gives an in-depth analysis of disputes over the proposed transboundary water-transfer schemes in the Okavango River. It should be remembered that the potential impact of such a scheme on the Okavango delta has made this basin a ‘‘hot spot’’ in terms of ‘‘environment or development’’ trade-offs. Chapter 8 (by Chenje) explores the possibility of establishing a river-basin organization (RBO) for the Zambezi River basin, the largest international river system in Southern Africa. The Zambezi River basin may become another hydropolitical hot spot of the region, and Chenje suggests that an RBO should be established for preventive diplomacy by riparian states. Abdullahi Elmi Mohamed, in chapter 9, puts forward a detailed comparative analysis of the Limpopo and Orange river basins. He vividly records how geopolitical differences have given rise to unique progress in each of these areas regarding dialogues among basin countries, although these river basins are located back-to-back in the region. Chapter 10 (by Meissner) deals with another international water system – the Kunene River – which is also of hydropolitical importance in the region, and gives a detailed analysis of the sensitive political agenda among stakeholders of the basin. The findings and suggestions in these chapters clearly show that a ‘‘one size fits all’’ type of simple solution is not at all possible for these international water systems, and that various issues specific to a river system should be carefully examined to elaborate a plan for better management of shared water resources.

Chapter 11 (by Adeel, Ballatore, and Giordano) touches upon the discussions made at the workshop held on 25 and 26 September 2000 in Sandton, South Africa, in which all the authors participated. It describes (a) previous work by the United Nations University in the field of international waters, which led to the workshop and, subsequently, to this volume, and (b) understandings and assumptions shared by the authors as a common agenda in elaborating chapters.

To fulfil the aim of this volume, authors were given the following mandate in developing their chapters: practical suggestions and/or estimation should be given, regarding the particular subject of the chapter, about ‘‘to what extent we may proceed’’ under the prevailing political circumstances and technical constraints, not about ‘‘where we should go’’ on the basis of idealistic/unrealistic assumptions. In other words, as the editor of this volume, I was keen to see in each paper ‘‘what may/could happen in the near future under existing constraints,’’ not ‘‘what should happen if everything goes well.'' This policy in developing this volume was reiterated at the workshop, and I can state without hesitation that all authors adhered to this policy in developing their chapters.

To what extent may this volume prove useful in assisting people in the Southern African region? I am very optimistic in this regard after repeated perusal of the manuscript; however, the final answer to this question should be left to you, the readers of this volume.

This Introduction should not end without an expression of my sincere thanks to many people who helped to produce this volume. First, I thank all the authors, who painstakingly followed my suggestions from preparation of their first draft up to the final version. Special thanks should be given to Dr Thomas Ballatore, who undertook all the administrative tasks associated with the workshop. Thanks are also due to those whose names do not appear in this volume as authors. For example, Dr Libor Jansky, Senior Academic Officer of UNU, and his assistant Ms Hiroko Kuno were very kind and patient in guiding my footsteps during the long process of preparation of this volume, which would not have materialized without their care and attention; Dr Juha Uitto, former Senior Academic Officer of UNU, initiated the UNU's project for this volume and gave me a number of helpful suggestions regarding project formulation; Professor Asit Biswas, the Chair of the ad hoc Committee on International Cooperation of the International Water Resources Association (IWRA), also provided me with useful guidance in organization of the workshop and preparation of the volume. Last but not least, special thanks should be given to those members of the UNU Press who helped me to prepare this volume for publication.

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1

Water-resources management in Southern Africa

Piet Heyns

Introduction

In the Southern African Development Community (SADC) region, water is generally in short supply compared with that in other parts of the world; this is due to low and variable seasonal rainfall, combined with high potential evaporation. Water sources may also be located far from demand centres and this complicates the transport and distribution of water.

As water flows through the landscape, whether on the surface or underground, it is not normally confined to one private property in a country, nor are the watercourses of the large rivers contained within the borders of a single state. Where large rivers or their tributaries flow from one state to the other, or form the boundaries between states, they are referred to as shared watercourse systems or international rivers.

Sharing water entails the apportionment of water from a common resource to certain consumers for specific uses and usually implies that everyone should receive at least an equitable, reasonable, beneficial, and environmentally sustainable portion. Difficulties in achieving these objectives may result in poor access to water for many people. In turn, poor access to adequate water sources is usually a major constraint to the improvement of the existing socio-economic situation in any country and limits the opportunities for further development. Consequently, the need to obtain access to shared water sources can become a cause of international and regional conflict.

Although it is clear that water resources should be shared between different users, not only are the available water sources scarce and finite but also the numbers of consumers continue to increase. Therefore, the only assurance that no harm is done to the interests of any party lies in the process of collaboration and negotiation to facilitate the sustainable management of water, including all the other available natural resources interlinked with water.

The purpose of this chapter is, therefore, to highlight the existing and planned water projects in the international river basins in the SADC region as well as the degree of cooperation that exists between the basin states in the sharing of water and the joint development of infrastructure to utilize those resources.

The international river basins in the SADC

Although there are 14 SADC states, only 12 of those states are located on the Southern African subcontinent: these are the republics of Angola, Botswana, Malawi, Mozambique, Namibia, South Africa, Zambia, and Zimbabwe; the United Republic of Tanzania and the Democratic Republic of Congo; as well as the kingdoms of Lesotho and Swaziland.

The international boundaries of those states were drawn in the second half of the nineteenth century by the colonial powers; this was an attempt to avoid conflicts between themselves as a result of the intense competition for territory at that time. The boundaries were determined through bilateral negotiations and subsequent demarcation by using straight lines between clear geographic features such as mountain peaks and watersheds or by following river courses to describe the boundaries. Those decisions never took cognisance of the extent to which groups of people with common historical, cultural, and economic interests were arbitrarily divided – least of all, how it would affect the concept of the integrated management of a river basin as a single unit.

A river basin or catchment area is recognized as the only natural unit for integrated river management; however, owing to political boundaries, water-resources planning, development, and management tends to be fragmented between local communities within a nation or even between nations. This emphasizes the need for better understanding and more cooperation between the basin states in order to prevent conflict in the allocation of a fair share of water to each consumer.

The boundaries of the 12 SADC states in Southern Africa (and of another 11 non-SADC countries) lie across 15 major perennial and ephemeral international river basins as reflected in table 1.1 and in figure 1.1.

Table 1.1 Location of river basins and basin states

River basin	Number of states	Basin states
Kunene	2	Angola, Namibia
Cuvelai	2	Angola, Namibia
Okavango	3	Angola, Botswana, Namibia, Zimbabwe
Orange	4	Botswana, Lesotho, Namibia, South Africa
Maputo	3	Mozambique, South Africa, Swaziland
Umbeluzi	2	Mozambique, Swaziland
Incomati	3	Mozambique, South Africa, Swaziland
Limpopo	4	Botswana, Mozambique, South Africa, Zimbabwe
Save	2	Mozambique, Zimbabwe
Buzi	2	Mozambique, Zimbabwe
Pungué	2	Mozambique, Zimbabwe
Zambezi	8	Angola, Botswana, Malawi, Mozambique, Namibia, Tanzania, Zambia, Zimbabwe
Rovuma	3	Malawi, Mozambique, Tanzania
Congo	9	Angola, Cameroon, Central African Republic, Congo, Democratic Republic of Congo, Burundi, Rwanda, Tanzania, Zambia
Nile	10	Tanzania, Burundi, Egypt, Eritrea, Ethiopia, Kenya, Rwanda, Sudan, Uganda, Democratic Republic of Congo

In table 1.1 it is interesting to note that the territory of one of the SADC states (namely, Tanzania) falls within the Nile River basin, of which the largest portion falls outside the SADC region.

In table 1.2 the number of international river basins within each SADC state is shown. Both Botswana and Namibia, which are the most arid of the SADC states, have access to at least four and five international river basins, respectively. Mozambique is party to nine international river basins (the most of all the SADC countries); however, in each case the country is at the bottom end of the particular river system.

In table 1.3 more details are given regarding the catchment area, topography, river length, and virgin run-off of each river basin where it terminates, in either an ocean or an endoreic (inland) basin.

Existing and proposed water projects on the shared rivers in the SADC

The Buzi River basin

The Buzi River originates to the south of Mutare in the eastern highlands of Zimbabwe before it cascades down to the coastal plains of Mozam-

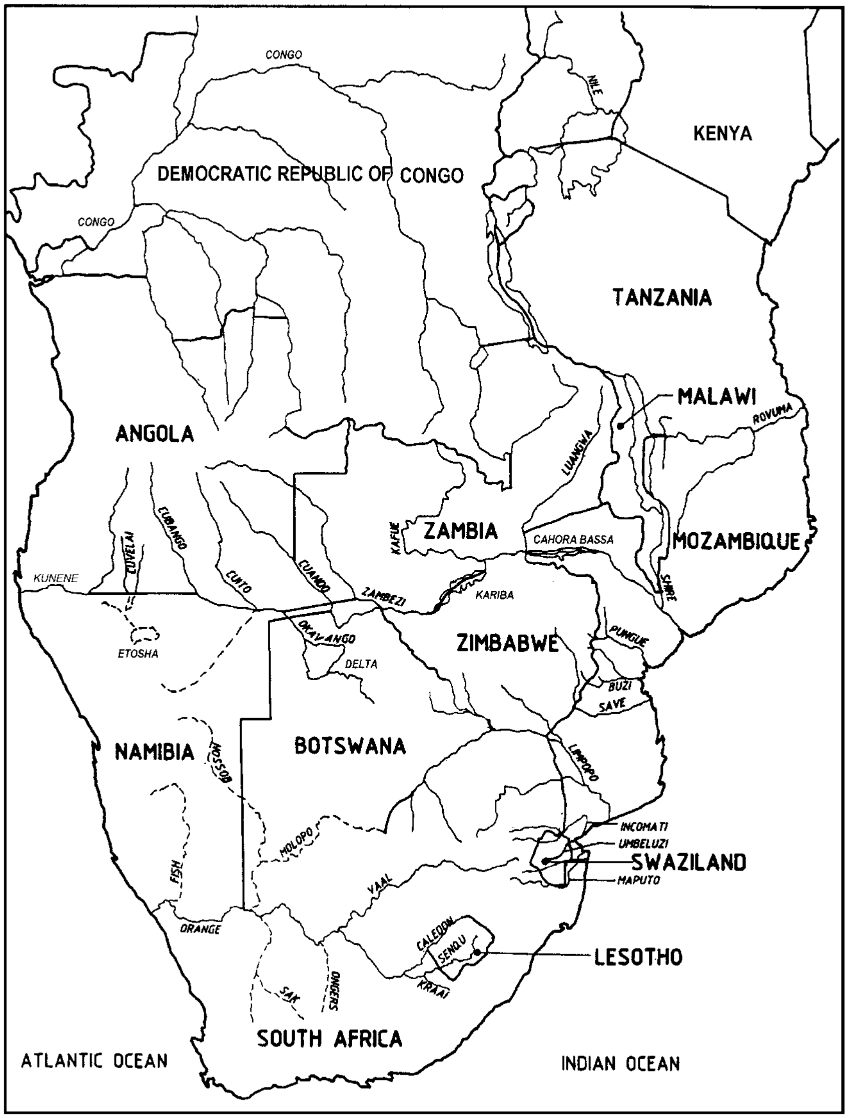

Figure 1.1 International river basins in the Southern African Development Community

bique. The mouth of the river is 25 km south of the important harbour of Beira on the Indian Ocean. The major tributary of the Buzi is the Revué.

The Chicâmba Dam, which can impound 450 Mm^3 (million cubic metres; MCM), has been built for water supply, irrigation, and power

Table 1.2 Shared river basins within the SADC states

SADC basin state	Number of basins	River basin(s) covered
Angola	5	Kunene, Cuvelai, Okavango, Congo, Zambezi
Botswana	4	Limpopo, Okavango, Orange, Zambezi
Democratic Republic of Congo	2	Congo, Nile
Lesotho	1	Orange
Malawi	2	Rovuma, Zambezi
Mozambique	9	Buzi, Incomati, Limpopo, Rovuma, Save, Maputo, Pungué, Umbeluzi, Zambezi
Namibia	5	Kunene, Cuvelai, Okavango, Orange, Zambezi
South Africa	4	Incomati, Limpopo, Maputo, Orange
Swaziland	3	Incomati, Maputo, Umbeluzi
Tanzania	4	Nile, Rovuma, Zambezi, Congo
Zambia	2	Zambezi, Congo
Zimbabwe	6	Buzi, Limpopo, Okavango, Pungué, Save, Zambezi

Table 1.3 Geographic details of the shared SADC river basins

River basin	Catchment area (km^2)	Elevation amsl[a] (m)	River length (km)	Mean annual run-off[b] (MCM[c]/year)
Buzi	31,000	1,000	250	2,500
Kunene	106,500	1,900	1,050	5,500
Cuvelai	100,000	1,500	430	130[d]
Incomati	50,000	1,100	480	3,500
Limpopo	415,000	1,100	1,750	5,500
Maputo	32,000	1,200	380	2,500
Nile	2,800,000	1,500	6,800	86,000
Okavango	530,000	1,700	1,100	10,000[e]
Orange	850,000	3,300	2,300	10,000
Pungué	32,500	1,400	300	3,000
Rovuma	155,500	1,500	800	15,000
Save	92,500	1,400	740	7,000
Umbeluzi	5,500	1,100	200	600
Zambezi	1,400,000	1,500	2,650	94,000
Congo	3,800,000	1,760	4,700	1,260,000

[a] Above mean sea level.
[b] At the mouth of the river.
[c] Million cubic metres.
[d] At the ephemeral, endoreic Etosha pan.
[e] At the perennial, endoreic, ‘‘panhandle’’ of the Okavango delta.

supply on the Revué River near Chimoio on the Beira–Mutare road in eastern Mozambique. The installed capacity is 38 MW. About 60 km lower down the river, at Mavuzi, more power is generated with an installed capacity of 52 MW.

The Kunene River basin

The Kunene River (known as the Kunene River in Angola) originates near Huambo in the Sierra Encoco Mountains in south-western Angola. The river flows in a southerly direction to the Ruacana Falls, where it turns to the west and proceeds to the Atlantic Ocean. The lower section of the river cuts through a deep gorge which starts at the Ruacana Falls. In the 340 km between Ruacana and the Atlantic Ocean, the river falls more than 1,100 m; this important feature provides the Kunene River basin with a hydroelectric power potential of approximately 2,400 MW.

Between 1926 and 1969, the Portuguese and South African governments entered into three Water Use agreements on the Kunene. In the First Agreement of 1926 it was agreed that Namibia has the right to one-half of the flow of the Kunene, provided that a water scheme for such a purpose would be feasible. The Second Water Use Agreement in 1964 related in general to the utilization of rivers of mutual interest between the parties, implying the inclusion of other rivers, such as the Cuvelai and the Okavango in Angola, or river systems, such as the Limpopo and Incomati in Mozambique. In that Agreement, the principle of best joint utilization was accepted and was defined as the allocation and utilization, on an equitable basis, of shared water resources with a view to achieving the optimum benefit for the states concerned, within the limits of the available quantity of water. This Agreement has also been acceded to by one other country, the Kingdom of Swaziland, in 1967.

The detailed feasibility investigations and related activities for the first phase of development of the hydropower potential of the Kunene River and the diversion of water into northern Namibia, set in motion by the 1964 Agreement, culminated in the Third Water Use Agreement of 1969, which initiated the construction of the proposed Kunene River Scheme. This Agreement established a Permanent Joint Technical Commission (PJTC) and made provision for Namibia to abstract water (maximum 6 m^3/s) at Calueque for diversion to the Cuvelai basin in northern Namibia. The project comprised the Gove Dam to regulate the flow of the Kunene River, the Calueque Dam and Pump Station for the diversion of water into Namibia, the Ruacana Weir for the diversion of water into the Ruacana Power Station, and the power station itself. Of this infrastructure (refer to table 1.4 for more detail), the Calueque Dam was

Table 1.4 Major dams in the Kunene River basin

Country and river	Dam	Dam capacity (MCM)	Surface area (km^2)	Use of dam[a]
Angola				
Kunene	Calueque[a]	475	180.6	a
	Gove[b]	2,575	178.2	b
	Matala[c]	60	40.8	c
	Ruacana[d]	30	5.0	d
Angola/Namibia				
Kunene	Epupa[e] (proposed)	7,300	295	e

1: Diversion of water to northern Namibia (pumpstations completed, dam incomplete);
2: Flood regulation for Ruacana power station (completed 1975). At present, damaged owing to military activities;
3: Domestic water supply, power supply, and irrigation;
4: Diversion of water into the Ruacana Power Station;
5: Hydropower generation; feasibility study completed.

never completed, owing to the war in Angola at the time. The Gove Dam was completed in 1975 and the works at Ruacana in 1978. The Ruacana Power Station, with an installed capacity of 240 MW that can generate 1,055 GWh/year, is located in Namibia. This facility has not been operating at its full capacity because the flow of the Kunene was not continuously regulated at Gove. This situation is currently being discussed by the PJTC to restore the obligation of Angola to regulate the flow.

At present, the total development of the Kunene River includes the multi-purpose hydropower and irrigation scheme at Matala in Angola. The hydropower facilities at Matala were upgraded from 27 MW to 40 MW in 1989, but the 3,000 ha of land available for irrigation is not cultivated because of damage to the canal system. Namibia can, at present, divert 3.2 m^3/s from the Kunene River at Calueque across the watershed to the Cuvelai drainage basin to supply the domestic and irrigation water demand in northern Namibia. In September 1990, some 6 months after the independence of Namibia, the governments of the republics of Angola and Namibia endorsed and affirmed the previous agreements reached between Portugal and South Africa. The PJTC was reinstated, but the Joint Operating Authority for the Kunene basin has not yet been re-established. The PJTC was also given the task of investigating possible new developments on the Kunene River.

The future development of the Kunene basin received immediate attention under the auspices of the PJTC. A pre-feasibility study on the

Table 1.5 Kunene River basin hydropower developments

Year	Facility	River	Country	Capacity (MW)
1954	Matala A	Kunene	Angola	27
1978	Ruacana	Kunene	Namibia	240
1989	Matala B	Kunene	Angola	13
2002	Epupa/Baynes	Kunene	Angola/Namibia	400
Total				680

proposed Epupa Dam hydropower scheme was completed in September 1993. The subsequent feasibility study on this project commenced towards the middle of 1995 and called for a complete re-evaluation of the hydropower potential of the lower Kunene. Several alternative dam sites were investigated and this led to the completion of a feasibility study that proposed two alternative hydropower schemes on the lower Kunene River (Epupa and Baynes). The proposed installed capacity will be about 400 MW and will be able to generate about 1,600 GWh/year. On completion of either one of the alternatives, the total installed power-generating capacity of the Kunene will be about 700 MW. Refer to table 1.5 for more detail on the existing and most recently proposed hydropower developments in the Kunene Basin.

The proposed development of the Epupa Dam raised a number of environmental concerns, such as the impact that the project would have on the lifestyle of the Himba people and the inundation of the Epupa Falls. At present, the development of further hydropower schemes on the lower Kunene is on hold because the Angolan Government prefers the Baynes site – which is technically, economically, and environmentally not the most optimal site in the Namibian view.

Other objectives on the Kunene are the rehabilitation of the Matala irrigation scheme, the rehabilitation and completion of the Calueque Dam embankment, and the upgrading of the pumping station at Calueque to abstract the agreed quantity of 6 m^3/s from the Kunene for transfer to Namibia. New studies of the hydrology of the Kunene basin will be undertaken in the near future, probably as part of the proposed SADC Energy Project 3.0.5.

The Cuvelai River basin

The Cuvelai River is an endoreic river, rising in the southern foothills of the Sierra Encoco in south-western Angola. It drains southwards towards the Etosha pan in northern Namibia. The Cuvelai is perennial for about 100 km before it ramifies into a delta of ephemeral watercourses which cross a broad plain of low relief; this delta converges again to terminate in the ephemeral Etosha pan. The watercourses, called oshanas, are the lifeblood of an area where 700,000 people (or just less than half of the population in Namibia) live.

Because of the arid climatic conditions, surface waters and shallow wells dry up from time to time. The groundwater is saline and the only way to augment these rather unreliable water supplies is to import water from the perennial Kunene River. This is the main reason for diverting water from the Kunene River basin to the Cuvelai basin. The water scheme is operated by the Namibia Water Corporation on Angolan territory and serves as an excellent example of cooperation between basin states. The existing water-supply network, distributing water through canals and pipelines to the population, is one of the largest in Southern Africa.

It is clear that any alteration to this international watercourse system in Angola or Namibia will have major repercussions for the fragile, semi-arid ecosystem and the people living on the flood plains. However, there is no specific international agreement between Angola and Namibia on water allocation or further studies in the Cuvelai basin.

The Incomati River basin

The Incomati River rises in the south-eastern Transvaal in South Africa. Its major tributaries in South Africa are the Lomati, the Crocodile, the Sabie, and the Sand; those in Mozambique are the Massintonto and Mazimchopes. The Incomati descends from a highland plateau in South Africa, cutting through a valley 900 m deep in northern Swaziland before crossing South Africa again and passing through a narrow valley in the Lebombo Mountains on the border between South Africa and Mozambique. The Crocodile River joins the Incomati upstream from this gap through the mountain called Komatipoort. Downstream of this 200 m deep valley, the river flows through the coastal plains of Mozambique in a northerly loop, turning south-west to the Indian Ocean. The lower reaches of the river are swampy where it flows into Lake Chuali and then to the sea, some 30 km north of Maputo.

Ten dams with storage capacities in excess of 12 MCM have been built on the river (eight in South Africa; two in Swaziland). The Sterkspruit Dam in South Africa is the largest and has a storage capacity of 167 MCM (Department of Water Affairs and Forestry 1986).

In Swaziland, the water from the Incomati is diverted to irrigate some 12,000 ha of land in the Incomati basin and across the watershed between the Incomati and the Umbeluzi rivers. A weir on the Incomati diverts 12 m^3/s into an irrigation canal 67 km long. Water is also pumped out of the canal to the Sand River Dam, which serves as a storage reservoir to provide additional water during low-flow periods in the Incomati. This project was completed in 1964 and has proved to be a very successful irrigation scheme, producing sugar, rice, and citrus.

As far as institutional arrangements are concerned, a Tripartite Permanent Water Commission was formed between Mozambique, South Africa, and Swaziland concerning the Incomati and Maputo River basin, but this Commission has not been functioning well since its inception. However, a Joint Water Commission has been established between South Africa and Swaziland; this Commission functions well and has created the Komati Basin Water Authority to prepare a Komati River Basin Development Plan. This plan was completed and facilitated the development of two dams, the Driekoppies Dam in South Africa (completed) and the Maguga Dam in Swaziland (under construction): the Driekoppies Dam will inundate a portion of the Kingdom of Swaziland; the Maguga Dam will supply water for irrigation. These dams are part of a multiphase joint-venture project aimed at joint management of the water resources of the Incomati River and to provide water for existing and new areas for irrigation purposes. Mozambique agreed to these developments, provided that an agreed minimum discharge of water was available at the border.

There is also a joint water-availability study on the Incomati basin and cooperation between South Africa and Swaziland is satisfactory. The cooperation of the third party, Mozambique, has been obtained to complete a management study on the basin. The proposed Injaka Dam on the Sabie River in South Africa is currently under construction.

The Limpopo River basin

The north-flowing tributaries of the Limpopo River orginate in South Africa along the northern slopes of the Witwatersrand, which forms the watershed between the Limpopo and Orange River basins. The east-flowing tributaries come from Botswana, and south-flowing tributaries start along the watershed between the Limpopo and the Zambezi rivers in Zimbabwe.

The water resources of the Limpopo Basin have been very well developed. Of the many dams that have been built in the basin to supply water for cities and towns, as well as to support industry and agriculture, 43 have a storage capacity of more than 12 MCM (Botswana 3, Mozambique 2, South Africa 26, Zimbabwe 12) (Department of Water Affairs and Forestry 1986); of those dams, 12 have a storage capacity of more than 100 MCM (Botswana 1, Mozambique 1, South Africa 7, Zimbabwe

3). The largest dam is the Loskop Dam on the Olifants tributary, which can impound 348 MCM.

In Zimbabwe, the river has been developed to nearly its full potential and the remaining run-off makes a very small contribution to the flow in the Limpopo.

The Botswana Government recently completed a new dam, the Letsibogo Dam on the Motloutse tributary, to augment the water supply to Gaborone via the proposed North–South Carrier which is currently under construction. It is also possible to augment the supply of water to Gaborone from the Molatedi Dam on the Great Marico tributary of the Limpopo in South Africa.

The Joint Upper Limpopo Basin Study by Botswana and South Africa has been completed and three proposed dam sites (at Cumberland, Martins Drift, and Pont Drift) have been investigated.

Mozambique has voiced concern about the reduction in run-off to the Massingir Dam on the Elefante tributary of the Limpopo, and all four basin states (Botswana, Mozambique, South Africa, and Zimbabwe) agreed to revive the Limpopo Basin Permanent Technical Committee. The Committee recently completed a monitoring study (hydrology) of the Limpopo and is currently drafting terms of reference for a development study of the whole basin.

A number of important interbasin water transfer schemes relate to the Limpopo River. From table 1.6 it can be calculated that South Africa has the capacity to transfer 700 MCM water annually from other international river basins (Orange 510 MCM/year, Incomati 100 MCM/year, and Maputo 90 MCM/year) to the Limpopo basin; there is also the capacity

Table 1.6 Water-transfer schemes in the Limpopo basin

Transfer scheme	Capacity (m^3/s)	Head (m)	Distance (km)
To the Limpopo basin	19.7	–	–
From the Orange Basin			
• Vaal–Olifants	7.7	142	50
• Vaal–Crocodile	12.0	–	–
From the Incomati Basin			
• Incomati–Olifants	3.8	7.50	150
From the Maputo Basin			
• Usutu–Olifants	3.4	445	115
Within the Limpopo basin			
• Great Marico–Notwane	0.3	400	350

to supply 9.5 MCM/year from the Molatedi Dam on the Great Marico River to Gaborone on the Notwane River in Botswana.

The Maputo River basin

The Maputo River rises on the border between northern Natal, south Swaziland, and the south-eastern Transvaal.

Four dams, which can store more than 12 MCM each, have been built on the tributaries of the Maputo in South Africa and two in Swaziland. The largest dam in the Maputo basin is the Pongolapoort Dam in South Africa, which can impound 2,500 MCM and inundates a portion of Swaziland (Department of Water Affairs and Forestry 1986). The water in the Maputo River basin in South Africa is diverted from the Usutu catchment and the Pongola catchment for industrial use and the cooling of power stations in the Limpopo River basin (Olifants River catchment) and the Orange River basin (Vaal River catchment).

The Nile River basin

Although Lake Victoria is generally seen as the origin of the Nile, that river actually rises as the Kagera River in Burundi and is contiguous to Rwanda and Tanzania before it flows into the lake. As the development of water resources in the Nile River basin is of no real consequence to the SADC States, it is not discussed further in this chapter.

The Okavango River basin

The Cubango River rises in the south-western Angolan highland, near and just east of the source of the Kunene and Cuvelai rivers. The Cubango flows for more than 600 km from the upper catchment in a southerly direction until it reaches the West–East cut-line through the vegetation that indicates the (unfenced) border between Angola and Namibia. From that point, the river forms the border between Angola and Namibia over a distance of some 400 km. It then turns southwards again and ends in the Okavango Swamps in Botswana. The mean annual run-off of the Okavango River at Muhembo on the border between Botswana and Namibia is 10,000 MCM.

The main tributaries of the Okavango are the perennial Cuito River and the ephemeral Omatako River. The Cuito River rises in the highlands in the central Cubango Province of Angola and contributes half the flow of Okavango River; the Omatako River rises near the Omatako Hills in central Namibia, but contributes nothing to the flow of the Okavango River.

Very little is known about water-resource development in the upper reaches of the Cubango and Cuito in Angola. It is thought that virtually no development has taken place in the catchment since the start of the civil war in Angola in 1975.

It is estimated that about 20 MCM water is abstracted annually from the Okavango River for domestic consumption and irrigation in Namibia. A dam has been built in the upper catchment of the Omatako River as part of the Eastern National Water Carrier (ENWC) project to divert water for domestic and industrial consumption in the Windhoek–Okahandja–Karibib complex in the Swakop River catchment in central Namibia. The ENWC will eventually be linked to the Okavango River at Rundu (Department of Water Affairs 1974).

No major development of the water resources of the Okavango River or the delta have taken place in Botswana, except for the Mopopi Dam, which was built to supply water to the Orapa diamond mine and was created by using the basin of the Putimolonwane pan and constructing earth embankments around it to impound more water. The reservoir capacity is 100 MCM and it covers 24.3 km^2 at full supply. Water is pumped into the dam from the Boteti River, which is the outflow river of the Okavango delta; this system has been replaced with groundwater because of the weak outflow from the delta. The development of the proposed Southern Okavango Integrated Water Development Plan in Botswana was shelved temporarily in 1992 before a draft of the review report by the World Conservation Union (IUCN) (Manley 1993) on the project was published in October 1992.

Little is known about future upstream developments in Angola. However, Namibia will have to import water from the Okavango River to supplement supplies to the central area of the country as early as the year 2005 and not later than 2009. The water project to achieve this objective, the ENWC, has been under construction in phases since 1969. The project links three state dams in the central area of Namibia and groundwater resources at Grootfontein in the north; however, the final phase, which is a pipeline of about 250 km between Grootfontein and the intended abstraction point on the Okavango River at Rundu, has yet to be constructed. The intention is to abstract 4 m^3/s (or 100 MCM/year) from the Okavango by the year 2020, and Botswana is aware of this requirement.

The institutional arrangements concerning the utilization of the Okavango Basin have been under discussion between the three basin states since 1992. The existing PJTC between Angola and Namibia (which deals with the Kunene River basin), and the existing Joint Permanent Water Commission between Botswana and Namibia, established to deal with the utilization and management of common water resources (such as the Okavango, the Cuando–Linyanti–Chobe System, and other water resources such as groundwaters) did not incorporate all three basin states in one Commission on the Okavango Basin. In view of the absence of an instrument of cooperation between all three basin states on the Okavango, the Namibian Government took the initiative by bringing the members of the existing commissions together to establish a Tripartite Water Commission on the Okavango basin. This endeavour came to fruition in September 1994, when a permanent Okavango River Basin Commission (OKACOM) was established between Angola, Botswana, and Namibia.

The OKACOM agreed to study the potential of the Okavango River basin and to develop an integrated management plan. This would be achieved by executing a comprehensive environmental assessment of the basin in order to determine the possibilities for development, the water requirements, the impacts of the proposed development projects, and the measures required to reduce any adverse impacts as much as possible. The OKACOM also decided to approach the Global Environmental Facility (GEF) to provide resources to support this initiative. Funding was provided for a transboundary diagnostic assessment (Permanent Okavango River Basin Water Commission 1999) and the GEF subsequently indicated its further interest in funding the development of a strategic action plan that would eventually lead to the formulation of an integrated management plan for the basin.

Owing to an unexpected drought in Central Namibia between 1994 and 1997, there was a real threat that the internal water resources would not be able to meet the managed water demand. Preventative measures had to be taken to develop the required infrastructure, on an emergency basis if required, to link the internal water resources by means of a pipeline to the perennial Okavango River. The Namibian Government informed Angola and Botswana about its planned measures to execute the necessary feasibility studies possible within the emergency time constraints. However, the possibility of this development resulted in a very negative response from the environmental community, who expressed concern only about the perceived negative impact of the proposed project on the Okavango delta ecosystem. Although the whole project was planned and ready for implementation by August 1997, an excellent 1997/98 rainy season allowed the project to be delayed for a number of years, well into the first half of the first decade of the new millennium.

The Orange River basin

The Orange River basin has four basin states – namely, the Kingdom of Lesotho and the republics of Botswana, Namibia, and South Africa. The river rises 3,300 m above mean sea level in the Mont-aux-Sources

Mountains in north-eastern Lesotho and flows for 2,300 km before discharging into the Atlantic Ocean. The main tributaries of the Orange are the Senqu in Lesotho, the Caledon (which forms the border between western Lesotho and South Africa), the Vaal in South Africa, the Molopo and Nossob rivers (which form the border between southern Botswana and South Africa), and the Fish River in Namibia. The natural (virgin) mean annual run-off of the Orange River is 10,000 MCM at the coast.

The ephemeral Molopo River is blocked by Kalahari Desert dunes downstream of its confluence with the Nossob River from Namibia and never reaches the Orange; these rivers can therefore be seen as an endoreic system. The Nossob River originates in the central highlands of Namibia, but the ephemeral summer run-off rarely reaches the confluence with the Molopo. The Oanob River, which rises to the south of Windhoek, is an ephemeral endoreic river in Namibia, within the Nossob catchment.

The Fish River originates in the Zaris Mountains near Maltahöhe in Namibia and flows into the Orange River some 112 km from the Atlantic. The mean annual run-off of the Fish River where it flows into the Orange River is about 500 MCM.

The water resources of the Orange River are certainly the most developed of all in the SADC Region. A number of major water projects have been completed in the Orange River basin (Department of Water Affairs and Forestry 1986) and 31 dams with storage capacities of more than 12 MCM each have been constructed (South Africa 24, Namibia 5, Lesotho 2). The most notable development in recent years is the Lesotho Highlands Water Project (LHWP), currently under construction. The LHWP is a four-phase project that will eventually be able to generate hydroelectric power (110 MW) and transfer water (70 m^3/s) to South Africa. The project entails the construction of five major dams and one smaller one, two hydropower stations, three pumping stations, and 225 km of tunnels.

In spite of the international status of the Orange River system, international cooperation on the development of the river did not start until 1978, when Lesotho and South Africa established a Joint Technical Committee (JTC) to investigate the feasibility of the proposed LHWP. This project was already conceptualized by the early 1950s and became known as the Oxbow Scheme. In May 1979, the JTC completed its preliminary feasibility investigation and a decision was made by the two countries to proceed with a final feasibility study. Work on the LHWP started in 1987 after a treaty, which approved the proposed project and established a Joint Permanent Technical Commission (JPTC), had been signed in 1986 between the governments of Lesotho and South Africa.

Further institutional arrangements followed, with the creation of two autonomous statutory parastatal bodies – the Lesotho Highlands Development Authority (LHDA) in Lesotho and the Trans-Caledon Tunnel Authority (TCTA) in South Africa – each entrusted with the implementation of that part of the project situated in their respective territories. The JPTC has monitoring and advisory powers concerning the activities of the LHDA and the TCTA.

This project will enable South Africa to save on the capital and operational cost of transferring water from the Orange, downstream of Lesotho, to the Vaal River by bypassing Lesotho on the western side. In return for this saving, South Africa will pay a unit cost for the water as well as royalties to Lesotho for the next 50 years, after which the royalties will be renegotiated.

All the other water developments that took place in South Africa and Namibia were downstream of Lesotho. South Africa, which was the Mandatory of the Territory of South West Africa between 1920 and 1990, acted as administrator for Namibia and there was no sovereign state with which to negotiate regarding utilization of the waters of the Orange River downstream of Lesotho. Another, related, complication was the fact that the border between Namibia and South Africa was defined as a line rising on the northern bank, which effectively meant that Namibia had no access to the waters of the Orange River. However, in 1980 an Interim Government was instituted in Namibia and in 1987 the two governments agreed to cooperate on the utilization of the Orange River. They subsequently established a JTC; after the independence of Namibia in 1990, a Permanent Water Commission (PWC) was created in 1992 to facilitate further cooperation. The South African Government subsequently conceded that the earlier definition of the border along the Orange River was not according to internationally accepted principles and it was agreed to shift the border to follow the centre or deepest valley of the river. The border is currently being demarcated by a Demarcation Commission. Because the Molopo makes no contribution to the flow of the Orange, little discussion took place between Botswana and South Africa on the development of the Molopo or the lower Orange rivers.

It is clear that Namibia is at the bottom end of the Orange River system and that Namibia should be involved with water-resource developments in the upper catchment areas. This was emphasized when the Namibian Government was requested to raise no objection to the LHWP before the internationally financed construction could actually start. In 1994 the Namibian Government proposed that a Joint Permanent Orange River Basin Commission be established to coordinate future water-resource development between the basin states. The agreement between Botswana, Lesotho, Namibia, and South Africa on the establishment of a water commission on the Orange River (the Orange–Senqu Commission) was signed on 3 November 2001 at Okapuka near Windhoek in Namibia.

Namibia gave no objection only to Phase 1 of the LHWP project. Phase IA of the LHWP comprises the construction of the Katse Dam (180 m high), transfer tunnels with a total length of 51.4 km, a hydropower station (72 MW installed capacity) at Muela, and a 37 km long delivery tunnel to supply 18.2 m^3/s to South Africa; Katse Dam, Muela, and the transfer tunnels have been completed. Phase IB of the LHWP includes the construction of the Mohale Dam (146 m high), a 30.3 km transfer tunnel from the Mohale Dam to the Katse Dam, upgrading of the power station at Muela to 110 MW, and a second (37 km) delivery tunnel to increase the transfer of water to South Africa to 29.6 m^3/s. Construction on the Mohale Dam started in 1998; further development of phases 2–4 of the LHWP is under investigation and various options are being considered.

The dams on the Orange River in South Africa serve a variety of purposes, including water supply for domestic and industrial use, irrigation, and hydropower generation to a lesser extent. Some of the most impressive of these water-resource developments on the Orange are the Gariep Dam and the Vanderkloof Dam, which can impound 5,600 and 3,200 MCM, respectively (SANCOLD 1994). The Vaal Dam on the Vaal River supplies water to the Gauteng industrial complex, and the Sterkfontein Dam (which is the largest of its kind in the world without a spillway) augments the waters of the Vaal Dam. The huge Bloemhof Dam downstream of the Vaal Dam supplies water for irrigation: more than 300,000 ha of land is at present under irrigation in the Orange Basin and the consumption of water for irrigation is at least 2,800 MCM/year; however, only 2,000 MCM/year is used for domestic, industrial, mining, and power consumption (Department of Water Affairs and Forestry 1986). Owing to the general nature of the topography, the hydropower potential of the Orange Basin is very modest (table 1.7).

Table 1.7 Orange River basin hydropower developments

Year	Facility	River	Country	Capacity (MW)
1962	Hardap	Fish	Namibia	0.5
1971	Gariep	Orange	South Africa	320
1977	Vanderkloof	Orange	South Africa	220
1998	Muela	Senqu	Lesotho	72
Total				612.5

The Noordoewer/Vioolsdrift Irrigation Scheme (800 ha) is located on Namibian and South African territory. A treaty was signed in 1992 between the governments of Namibia and South Africa to establish a Joint Irrigation Authority; about 20 MCM/year is supplied from the Orange River to this scheme.

Another important water-resource development is the transfer of water from national and international river basins within South Africa to the international Orange River basin, the transfer of water from the Orange River basin in South Africa to other national and international river basins, and the transfer of water by Lesotho and South Africa within the basin. Examples of these are given in table 1.8, from which it can be calculated that, on the basis of the capacity of the water-transfer schemes, about 1,500 MCM water gravitates every year from the Orange River basin at the Gariep Dam via the Orange–Fish Tunnel (at 85 km the longest in the world) to the Great Fish River basin in the Eastern Cape Province of South Africa. The Great Fish River discharges into the Indian Ocean and some 30,000 ha is under irrigation with the water from the Orange River basin. The pumping of water from the Tugela River in Natal to the Vaal River catchment, which is part of the Orange River basin, takes place within the borders of South Africa and amounts to 725 MCM/year. The transfer of water from the Maputo River basin, which is shared between three basin states (Mozambique, South Africa, and Swaziland), is 200 MCM/year. The same applies to the annual transfer of 620 MCM of water from the Orange River basin (Vaal River) to

Table 1.8 Water-transfer schemes in the Orange River basin

Transfer scheme	Capacity (m^3/s)	Head (m)	Distance (km)
From the Orange basin	67.7	–	–
To the Fish River	48.0	Gravity	85
To the Olifants River	7.7	142	50
To the Crocodile River	12.0	–	–
To the Orange basin	29.4	–	–
From the Tugela basin	20.0	570	45
From the Buffels River	3.0	140	40
From the Assegaai River	6.4	385	60
Within the basin	56.6	–	–
Caledon to Modder	4.0	177	20
Orange to Riet	16.0	49	70
Orange to Vaal	7.0	39	20
Sengu to Vaal	29.6	Gravity	80

the Crocodile and Olifants rivers, which are major tributaries in the Limpopo basin, shared by four basin states.

These water-transfer schemes complicate the principle of equitable and beneficial utilization of the water resources of internationally shared watercourse systems because, in the case of the Orange River, it is clear that South Africa has the capacity to export 2,120 MCM/year from the basin and can import only 925 MCM/year, leaving a deficit of 1,195 MCM/year. The Lesotho Highlands Project will initially convey 930 MCM/year between the Senqu River in Lesotho and the Vaal River in South Africa within the Orange River basin. The capacity of all water-transfer schemes within the Orange River totals 1,780 MCM/year.

Water development in the Orange River basin in Namibia comprises the Otjivero Dam on the White Nossob tributary of the Nossob River, the Oanob Dam in the Oanob River, and the Dreihuk Dam on the Hom River. Two major dams have been built on the Fish River in Namibia, namely the Hardap Dam (1963) and the Naute Dam (1970). Both of these dams were built for domestic and irrigation (1,400 ha at Hardap) water supply, but the development of an irrigation scheme at Naute started only after the independence of Namibia.

The South African Government completed a comprehensive replanning study of the Orange River system, including the hydrology and water demands. Lesotho and Namibia are also participating under the auspices of their respective water commissions with South Africa. Future developments on the Orange River system will depend on this study, which also looks at the environmental water requirements and the huge water losses as a result of evaporation. The eventual viability of developing phases II, III, and IV of the LHWP, as far as it would affect a downstream country like Namibia, will have to be taken into consideration. In this regard the bilateral PWC will soon embark upon a preliminary feasibility study to improve the management of the water resources of the lower Orange River along the common border, and the possibility to develop a dam will also be investigated. The work started in January 2002.

The planned additional transfer of 40 m^3/s of water (LHWP phases 2–4) from the catchment in Lesotho to the Gauteng industrial complex in South Africa is of critical importance, and must be analysed very carefully, especially in view of other alternative transfer schemes in South Africa and the needs of the other basin states.

Further development on the Fish River in Namibia and at several places along the Orange River border with South Africa is currently under investigation in Namibia. These developments include the proposed Bruckaros Dam irrigation project; water for a new zinc mine near Rosh Pinah (Skorpion Mine); a proposed copper mine at Haib, near

Table 1.9 Estimated water demand in the Orange River basin

Type	1990	2010
Urban and industrial	1,381	2,792
Mining	176	411
Power	333	533
Irrigation	2,779	3,473
Stock	114	132
Environment	594	599
Total	5,377	7,940

Noordoewer; a gas-fired power station at Oranjemund; and further irrigation at Noordoewer, Daberas, and Aussenkehr in Namibia. The water demand on the Orange River system in 1990 and the estimated future water demand by the year 2010 is shown in table 1.9.

As the water demand in South Africa increases, the development of other resources will also have to be considered. South Africa investigated the possibilities of transferring more water into the Orange River basin from rivers flowing to the east from the Drakensberg massiv. These include studies on water transfers from the Umzimvubu basin to the Orange via the Kraai River, or increasing the existing supply from the Tugela by including the Spioenkop Dam and utilizing the rivers in the Maputo basin, or by transferring more water to the Gauteng area from the Orange River to the Vaal River catchment. The studies indicated that the most viable options would be the development of further phases of the LHWP or the transfer of water from Tugela. Other ‘‘sources’’ of water include greater emphasis on water conservation, demand management, effluent reuse, desalination, water reclamation, and the importation of water from further afield – for example from the Okavango or Zambezi river basins. Some of these developments relate to international rivers, and collaboration between the basin states is imperative.

The Pungué River basin

The source of the Pungué River is the eastern highlands of Zimbabwe to the north of Mutare. From there it crosses the coastal plains of Mozambique and enters the Indian Ocean at the port of Beira. The river is navigable for some 60 km upstream from Beira. The major tributaries of the Pungué are the Urema and the Muda.

Little development has taken place on the Pungué River, but Zimbabwe has constructed a dam to divert water from the headwaters of the Pungué in Zimbabwe for water supply to Mutare and to the Save River catchment. The water requirement for Mutare is 0.75 m^3/s, and 12.5 m^3/s will be made available for irrigation along the Save River. Zimbabwe has informed Mozambique of its plans to proceed with the project; the creation of a river commission between Mozambique and Zimbabwe is being considered to execute river-basin studies on the Pungué and the Save rivers.

The Rovuma River basin

The Rovuma River rises in the Matogaro Mountains in Southern Tanzania and flows eastward into the Indian Ocean. It forms the border for 650 km between Tanzania and Mozambique. The major tributary of the Rovuma is the Lugenda River, which originates at Lake Chiuta on the border between Malawi and Mozambique.

The flow of the Rovuma River has not been systematically gauged and little significant development has taken place. A preliminary study was undertaken in 1982 for the construction of a 2.0 MW hydropower plant to supply power to Tundura in Tanzania, but no further development took place. As there is no demand, no significant development on the Rovuma is planned for the near future.

The Save River Basin

The Save River and its major tributaries (the Odzi, Runde, Mutirikwi, and Turgwe) arise on the southern side of the watershed with the Zambezi, between Marondera in the east and Gweru in the west. These rivers flow southwards and turn to the east, where they converge before crossing the border with Mozambique and entering the Indian Ocean through swamps on the coastal plains.

At least 17 dams with a storage capacity of more than 12 MCM (7 can impound more than 100 MCM) have been built in the Save Basin to supply water to some 2.6 million people, irrigation schemes, and mining development. The largest dam, the Osborne Dam on the Odzi River, can impound 400 MCM. The estimated present consumption of water in the Save Basin within Zimbabwe is 1.25 MCM/year, and Zimbabwe is planning to divert 12.5 m^3/s from the Pungué River to the Save catchment for irrigation purposes. As a result of the present land-use patterns, erosion causes high silt loads in the river beds. A Pungué/Save Water Commission to regulate the water-resource development activities within the two river basins has been proposed. Zimbabwe is also planning the Mukosi Dam, with a capacity of 180 MCM, on the Tokwe River in the Save basin.

The Save Development Plan proposed by Zimbabwe envisages a considerable increase in water consumption in the Save basin in Zimbabwe.

The needs of Mozambique, as a downstream basin state, should therefore be taken into account by the proposed water commission.

The Umbeluzi River basin

The Umbeluzi River rises in the eastern mountainous highveld of Swaziland to the north of the capital Mbabane. The river flows in an easterly direction to Maputo, the capital city of Mozambique and a major harbour on the Indian Ocean. The main tributaries of the Umbeluzi are the White and the Black Umbeluzi in Swaziland as well as the Matola and the Tembre rivers in Mozambique.

The most important developments on the Umbeluzi are the Hawane and Mnjali dams in Swaziland as well as the Pequenos Libombos Dam, with a capacity of 400 MCM, in Mozambique. No immediate future development is envisaged in the Umbeluzi catchment, but there is a Joint Permanent Technical Water Commission between Swaziland and Mozambique that deals, *inter alia*, with the development of the Umbeluzi Basin.

The Zambezi River

The Zambezi River basin is the largest of the African river systems flowing into the Indian Ocean. It is shared by eight basin states and supports a population of more than 20 million people. The major tributaries of the Zambezi rise in Angola, Malawi, Tanzania, Zambia, and Zimbabwe. There are five major swamps – the Borotse, the Eastern Caprivi, the Kafue, the Busanga, and the Lukanga – covering an area of 20,000 km^2 at the height of the flood periods.

Apart from a number of smaller lakes, the most significant natural lake is Lake Malawi (30,000 km^2), but there are also two major artificial lakes – namely, Kariba (5,180 km^2) and Cahora Bassa (2,660 km^2). Other reservoirs with large surface areas are the Kafue Dam (809 km^2) and the Ithezithezi Dam (365 km^2). It is estimated that more than 160,000 metric tonnes of fish are caught every year in these bodies of water. The mean annual run-off in the Zambezi at selected sites is reflected in table 1.10

At least 28 dams with a storage capacity in excess of 12 MCM, of which Kariba is the largest (160,000 MCM) and Cahora Bassa the second largest (52,000 MCM), have been built for domestic, industrial, and mining water supply and for irrigation and power generation. The countries with dams are Malawi (1), Mozambique (1), Zambia (4) and Zimbabwe (21), plus Kariba, which lies between Zambia and Zimbabwe. At present there are at least 12 established hydropower facilities in the Zambezi basin, of which the major ones are at Victoria Falls, Kafue Gorge,

Table 1.10 Mean annual run-off in the Zambezi

Location	Mean annual run-off (MCM)
Kongola (on the Cuando in Namibia)	1,300
Katima Mulilo	41,000
Victoria Falls	38,000
Kariba Dam	46,000
Cahora Bassa Dam	88,000
Liwonde (Lake Malawi outflow)	15,000
Indian Ocean	94,000

Table 1.11 Zambezi basin hydropower developments

Year	Facility	River	Country	Capacity (MW)
1924	Mulungushi	Mulungushi	Zambia	20
1938	Victoria Falls	Zambezi	Zambia	108
1944	Lunsemfwa	Lunsemfwa	Zambia	18
1959	Kariba South	Zambezi	Zimbabwe	666
1966	Nkula A	Shire	Malawi	24
1971	Kafue Gorge	Kafue	Zambia	900
1973	Tedzani I & II	Shire	Malawi	40
1975	Cahora Bassa	Zambezi	Mozambique	2,075
1976	Kariba North	Zambezi	Zambia	600
1992	Nkula B	Shire	Malawi	100
1995	Wovwe	Songwe	Malawi	4.5
1996	Tedzani III	Shire	Malawi	50
1998	Kapichira 1	Shire	Malawi	64
2000	Kapichira 2	Shire	Malawi	64
Total				4,733.5

Kariba, and Cahora Bassa on the Zambezi and on the Shire River at Nkula A and B, Tedzani, and Kapichira (see table 1.11).

Some examples of potential hydroelectric developments are at Katombore upstream of the Victoria Falls; the Batoka Gorge (1,600 MW), and Devil's Gorge (1,240 MW) – both sites between the Victoria Falls and Lake Kariba; the Mupata Gorge (1,000 MW), located between Kariba and Cahora Bassa; as well as the development of the middle Shire River between Kholombidzo and the Hamilton Falls (with a potential 600 MW output, of which 339 MW has been developed so far). More dams are possible downstream of Cahora Bassa at Mpanda Unca, Baroma, Lupata, and Mutarare in Mozambique.

Although the available water resources in the Zambezi basin in general exceed the demand at present, this situation may deteriorate as a result of the increase in population, more industrial and mining development, increased irrigated food production, a higher standard of living of the population, and taking the environmental water demand of the system into account. However, it is estimated that the most significant increase in water consumption will most probably be as a result of large-scale irrigation projects. More than 250,000 ha of land is currently under irrigation but the development of large irrigation projects to secure the food-supply situation may become necessary and it is estimated that more than 500,000 ha of land could be brought under irrigation in the next 30 years.

Other development projects that have been proposed are a 40,000 ha irrigation project (with Shire River water) at Bangala in Malawi, a 10,000 ha sugar-cane project in the Eastern Caprivi in Namibia, the proposed Bulawayo Water Diversion Project in Zimbabwe to supply water for domestic and agricultural consumption from the Zambezi, and the abstraction of water from the Zambezi at Kazungula or Katima Mulilo in the Caprivi to augment the water supplies in Botswana (Ministry of Mineral Resources and Water Affairs 1991) and South Africa by the year 2020. Some of these proposed projects are also typical examples of projects that may not be feasible owing to their questionable economic viability (SARDC 1996).

It is clear that the Zambezi River is the main life-supporting artery of eight basin states, and that the creation of an effective river basin commission to manage this vital resource is crucial to the socio-economic well-being of all basin states.

The Congo River basin

The Congo River originates in highlands located in eight co-basin states. However, most of the contribution to the run-off at the mouth of the Congo River is generated in the middle courses of the river in the central tropical rain forests of the Congo basin on the equator. The flow in the upper reaches of the drainage basin is of lesser magnitude – especially in Angola, the Central African Republic, and Tanzania. The annual average run-off in the Congo River is 1,260,000 MCM and the average flow is 40,000 m^3/s. The historic minimum and maximum flows vary between 21,400 and 73,600 m^3/s, respectively, but 98 per cent of the time the river flow exceeds 26,400 m^3/s.

The main potential of the Congo River is for the generation of hydropower. There are many falls and rapids that provide potential sites for development. The river has a total theoretical generating capacity of 100,000 MW and the total generating capacity installed at present is more than 2,500 MW.

In spite of its many waterfalls and rapids, the Congo River is a very important waterway because the river is navigable over long distances and provides good opportunities for boat transport and trade between the basin states.

There are large wetlands and lakes in the Congo basin within Zambia and Tanzania that provide important grazing, fish, and wildlife resources for the population.

About 20 large dams have been built on the tributaries of the Congo River within the Democratic Republic of Congo, but none within the SADC Region. Most of the dams are used for water and power supply.

A major hydropower development on the Congo River is the Inga I and Inga II dams. They have a 350 MW and 1,400 MW (total 1,750 MW) installed capacity, respectively, but this is dwarfed by the proposed Grand Inga Dam, which will have a total installed generating capacity of 39,000 MW (equal to the total installed capacity in South Africa) or a power supply of 23×10^{12} kWh per annum. On completion, the Grand Inga Dam will be the largest hydropower facility in Africa (Olivier 1978).

There are no immediate plans for further development of water or electricity supply infrastructure on the Congo River, but the Namibian Head of State has mentioned the possibility of bringing water from the Congo River southwards to the more water-scarce countries – such as Namibia, Botswana, and South Africa. This proposal has been further elaborated by the Namibians and has been accepted as an SADC project. The first step would be a desk study to evaluate various alternatives for achievement of the objectives.

Important characteristics of the river basins in the SADC

The international rivers in the SADC region have several important general characteristics that influence their development potential and impact on international cooperation between the basin states, as follows.

- In all cases, the run-off that is supposed to be available in one country is mostly generated in mountainous areas in another country or countries – for example, the Orange along the Namibian–South African border.
- The run-off in all rivers is subject to marked seasonal and annual variations due to the climatic conditions.
- In some cases the contribution to the run-off in these rivers from the territory of one basin state is negligible, although access to the water is of critical importance to support development in that country – for example, the Save in Zimbabwe and the Okavango in Namibia.
- As a direct consequence of the variation in the annual and seasonal flows in the perennial rivers, dams must be constructed to regulate the

rivers to impound water for later supply to domestic and industrial consumers or for hydropower generation – for example, the dams on the Orange, the Zambezi, the Save, and the Kunene.

- The very low flows that occur from time to time during droughts exacerbate sharing of water between riparian states. Droughts, and the major floods that occur during the good rainy seasons, emphasize the need for international collaboration on river-basin management, the equitable allocation of water, and cooperation on joint infrastructure development.
- A very fortunate aspect of the international rivers in Southern Africa is that the chemical quality of the water is still very good because the concentration of total dissolved solids and pollution is low, and toxic substances are virtually absent. This is one aspect that can be disastrously impaired if water-quality management is neglected.
- The availability of suitable irrigable soils along the international rivers is, in general, much greater than the availability of water to support such irrigation. The application of water for irrigation will have to be adjudicated carefully as far as the economic viability, environmental sustainability, and most optimal or beneficial use of the water is concerned.
- The international rivers on the borders of the basin states are widely spaced and remotely located from centres of development in the interior of the countries. This situation places limitations on the use of the water, simply because of the huge capital investment required for infrastructure development over long distances to convey the water from the source to the consumer, and because of the operational costs incurred as a result of the high pumping heads and energy costs involved.

However, water-transfer schemes remain of vital importance to many countries (see table 1.12)

River-basin institutions to support cooperation

The responsibility to investigate, control, supply, and manage water resources in any country is mainly vested in a Department of Water Affairs, which may fall within the ambit of a particular ministry in a country.

Each state normally has its own concrete projects for harnessing water resources and, as is to be expected, its own ideas on the utilization of the resources of river basins that it shares with others. For example, one state may regard the generation of hydropower as the main objective, with complementary goals in the areas of transport, industry, and mining. Other states in the drier parts of the basin may elect to harness the water

Table 1.12 International inter-basin water-transfer schemes

Transfer scheme	Capacity (m^3/s)	Head (m)	Distance (km)
ANGOLA			
Angola–Namibia			
• Kunene–Cuvelai	3.2	20	300
LESOTHO			
Lesotho–South Africa (Orange)			
• Lesotho Highlands Water Project Phase 1A & 1B	29.6	gravity	115
NAMIBIA			
Eastern National Water Carrier			
• Okavango–Swakop	4.0	600	700
SOUTH AFRICA			
Incomati–Limpopo			
• Komati–Olifants	3.8	730	150
Maputo–Limpopo			
• Usutu–Olifants	3.4	445	115
Maputo–Orange			
• Assegaai–Vaal	6.4	385	60
Orange–Great Fish	48.0	gravity	85
Orange–Limpopo			
• Vaal–Olifants	7.7	142	50
• Vaal–Crocodile	12.0	–	–
Tugela–Orange			
• Tugela–Vaal	20.0	570	45
• Buffels–Vaal	3.0	140	40
South Africa–Botswana (Limpopo)			
• Molatedi Dam–Gaborone	0.3	–	60
South Africa–Namibia (Orange)			
• Vioolsdrift–Noordoewer	0.8	gravity	30
ZIMBABWE			
• Zambezi–Bulawayo (proposed)	2.0	$\pm$800	360
ZAMBEZI			
• Zambezi–Gauteng (concept)	100	$\pm$600	1,200

for objectives of equal importance to them, such as animal and human consumption, irrigation, and fish farming. Nevertheless, the water must be rationed among those who have interests in it, and the only means of doing this on a long-term basis is through cooperation, which has to be done in the context of a river basin as a complete unit. Of critical importance in this endeavour is that the parties understand the complexities of water in the environmental system.

The challenge facing water users in international river basins can be met only in a multi-disciplinary way. Such an approach calls for a major effort aimed at establishing proper institutional structures with adequate staff, with access to the multitude of disciplines in hydrology, engineering, agriculture, industry, economics, environmental sciences, and the social disciplines relating to human development – such as health and education.

Each basin state is entitled to an equitable and beneficial share of the waters of the international river basins to which it may have access; however, the realization that water resources must be managed sustainably in the river basin should be well established in all basin states. In many countries (especially the arid ones, such as Botswana and Namibia, or the possibly affected ones such as Mozambique), the waters of international watercourses are critical for sustained future socio-economic development within the borders of the country. Because of this situation, several technical water commissions have, in the past, been established between basin states to provide a forum for regional collaboration on water matters. The major advantages of such institutions, present and future, will be to promote understanding and mutual trust between the parties. The parties will have the opportunity to discuss mutual expectations and fears, but more clarity will be achieved after the parties decide to examine the potential of all the natural resources in an international river basin: this will enable them to base further negotiations on facts. In the process, expectations could be accommodated and all parties would be able to participate in joint planning to reach mutually beneficial agreements on the equitable development and utilization of the river-basin resources.

In general, the major objectives of these river-basin commissions are to direct studies on the natural resource potential of a river basin and to formulate an appropriate strategy leading to an integrated, equitable, economically viable, technically sound, and environmentally sustainable development plan to utilize all the resources of a river basin to the benefit of each basin state and to that of the basin as a whole.

Integrated river-basin planning and sustainable development cannot be achieved without assessment of the potential of the resource base and of all the social, economic, and environmental aspects relating to the equitable and beneficial utilization of the resources available. However, in many cases there is a severe lack of long-term data and it is, therefore, of paramount importance to embark upon the necessary investigations and research within the river basins, to exchange existing information, and to gather new data to develop an accurate database that can be used when the feasibility of any proposed infrastructure development project must be assessed in future. The need for baseline studies, starting long before any development takes place, is clear.

The most important functions (to name but a few) of a river-basin commission would be to exchange information, to procure funding for studies or projects, to collect and process data, and to assess the potential of all the natural resources in the basin. With this information at hand, it would be possible to discuss the equitable, beneficial, and environmentally sound allocation of water to each basin state in an informed and open way. All parties would be able to participate in the planning and implementation of joint projects to the benefit of all, as well as the sharing of costs, where applicable. Another very important responsibility of a river-basin commission is to maintain monitoring programmes, to monitor the operation of the scheme, to protect water quality, and to ensure that the environmental considerations receive proper attention. The importance of this collaboration in improving friendly relations and in developing mutual understanding and trust between the representatives of the parties involved should also not be overlooked (Heyns 1995).

In view of the fact that the principles of international water law may be useful to consider when disputes arise between the basin states, it is very important that early agreement is reached on the rules that would apply. In this regard, the Helsinki Rules of the International Law Association (International Law Association 1966), or the United Nations Convention on the Law of the Non-navigational uses of International Watercourses (United Nations 1997), or some form of arbitration may serve as a basis for negotiations, agreement, and dispute resolution.

In 1994, the SADC decided to create a Water Sector Coordinating Unit (WSCU) in Lesotho to facilitate integrated water-resource management and development in the region. One of the first major achievements of the WSCU was the finalization, signing, ratification, and entry into force of the SADC Protocol on Shared Watercourse Systems in the Southern Africa Development Community Region. By 1998 the WSCU had developed a five-year Regional Strategic Action Plan for Integrated Water Resources Development and Management in the SADC Countries (1999–2004) and about 30 regional water projects have been identified for execution. The WSCU also implemented a hydrological cycle observation system (HYCOS) in the SADC region; this system is currently being repaired because many of the stations were damaged during the floods in Southern Africa during the 1999/2000 rainy season.

The Southern African Technical Advisory Committee (SATAC) of the Global Water Partnership (GWP) also found its roots in the SADC region in 1998 and worked closely together with the WSCU and other stakeholders to produce a document, submitted at the Second World Water Forum in The Hague in March 2000, on the Southern African Vision and Framework for Action for Water, Life, and the Environment in the Twenty-first Century.

Potential hydropolitical hot spots

There will always be the potential for conflict when natural resources have to be shared. This is even more so with regard to the existing situation, where so many SADC countries share rivers as boundaries. Fortunately, this has been recognized by the SADC as a sensitive issue and steps have already been taken to manage the situation in an amicable way by the development and acceptance of the SADC Protocol on Shared Watercourse Systems (recently amended). Although there is a regional instrument of international water law, the United Nations Convention on the Law of the Non-navigational Uses of International Watercourses (adopted in 1997 by the General Assembly) provides further guidelines to regulate the sharing of international waters among the riparian states. In fact, the amended SADC protocol incorporated a number of these guidelines. Nevertheless, a number of the proposed developments could give rise to conflict, either by a disagreement between the riparian states or as a result of the intervention of concerned international conservation institutions. Some of these potential hot spots are:

- the development of further phases of the LHWP on the Orange River in Lesotho;
- the completion of the Eastern National Water Carrier in Namibia by the construction of the proposed Rundu–Grootfontein pipeline component, starting on the Okavango River;
- the construction of the Batoka Gorge hydropower scheme between Zambia and Zimbabwe on the Zambezi River;
- the development of the "Congo River Project," where a pipeline will have to cross war-torn Angola and the Democratic Republic of Congo on its way to the water-deficient South;
- the development of the proposed Epupa hydropower scheme between Angola and Namibia on the Kunene River;
- the proposed Divundu hydropower scheme on the Okavango, as well as the sugar-cane irrigation project on the Zambezi in Namibia, the Zambezi–Bulawayo water-transfer scheme in Zimbabwe, and the Mpande Uncua hydropower scheme in Mozambique;
- the supply of water to Botswana and South Africa from the Zambezi.

The development of these projects will, of course, depend on many factors, such as their economic feasibility, the extent to which they might cause significant harm to the other riparians, the question of what would be equitable and reasonable, as well as the identified environmental disadvantages that cannot be mitigated.

Some of the possible projects stated in the last item above may lead to conflicts from a somewhat different perspective, because the basin states can act unilaterally. In other words, cooperation on joint-scheme development is not necessary and provides a view on the other side of the coin where development can take place without wider consultation. The sovereign rights of the basin states and the political commitment towards the spirit of the SADC Protocol will play a major role in this regard.

Finally, it should be mentioned that the World Commission on Dams completed their work in November 2000. A new framework for decision-making was created and provides for the elevation of the social and environmental dimension in infrastructure planning to the same level as technical and economic considerations. This will certainly enhance the sharing of international waters for peace, development, and security.

Conclusions

The international boundaries of Africa were inherited from the colonial scramble of the nineteenth century, and the concept of keeping river basins within territorial boundaries simply never entered the issue. In the SADC region there are 15 international drainage basins that have been developed to some extent, but there still remains great potential for socio-economic development in the states that share them.

Basin states should not allow badly planned development and the deterioration of the environment to ruin the chances of beneficial use of the natural resources for future generations. Serious attention should be given to using an international whole-basin approach to regulate and manage these immense resources. By the same token, the full development and optimal use of the water resources will be hampered if they are unilaterally developed in each country as a purely national matter, without giving due consideration to the interests of the other basin states. This could even militate against international harmony and security and might result in armed conflict (Pallet 1997).

Many existing shared water-infrastructure developments and proposed new projects have been discussed in this chapter; however, in future there will be a greater need to align legal principles and rules with the physical and environmental laws that govern the natural occurrence of water. Countries therefore need to establish links to allow discussion and the exchange of views to facilitate mutual and beneficial cooperation in order to achieve better management of shared water resources. This will serve to promote the sustainable and environmentally acceptable development of those resources.

Whenever international water resources need to be utilized by the basin states, it will be in the interest of all parties to establish appropriate river-basin institutions to collaborate on the equitable and beneficial allocation of water for different uses. It is advisable that river-basin commissions should be formed without intervention from parties outside the river basin, in order to ensure internal sustainability. The commissions should be lean, efficient, and effective to function optimally; this can be achieved by limiting the permanent representatives of each basin state to such a commission (perhaps not more than three). Nevertheless, in the agreement between the parties, the commission must be given the necessary powers and authority to utilize the available technical and financial resources in each state, or to coopt competent experts, or to appoint specialist consultants to carry out specific tasks. It is important that each basin state utilizes its own resources as far as possible, to facilitate the sharing of costs and to contain expenditure.

It may be necessary for these institutions to raise funding to assist them to reach their objectives; in this regard, external support by interested cooperating partners would facilitate the sustainable utilization of all the natural resources. What is important is that the basin states should take the initiative to manage their resources; external support must be stimulated by the success of the activities of the commissions.

More attention should be given to integrated water-resources management in the SADC framework because no development would be sustainable without the availability of water. In view of all the existing and proposed new water projects mentioned, as well as the implementation of the SADC Protocol on Shared Watercourse Systems and the United Nations Convention on the Law of the Non-navigational Uses of International Watercourses, it is trusted that this chapter has provided some food for thought about the real need to move forward dynamically in the water sector.

Acknowledgements

The assistance of a number of colleagues who provided information and advice, as well as that of my secretary, Reta Markgraaff, who put everything together, is appreciated.

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