

SINK OR SWIM?:

Water, Resource Security and State Co-operation

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Water and Security in Southern Africa

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Resource-based Conflict: Water (In)security and its Strategic Implications

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A Synoptic View of Water Resources in Southern Africa

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WATER AND SECURITY IN SOUTHERN AFRICA

Hussein Solomon

Free from the bipolarity of Cold War international politics that has brought about conflict, mainly based on ideological differences, the world increasingly witnesses the potency of resource-based conflict. One such potential conflict area is scarce fresh water resources. It has been estimated that 1,7 billion people, spread over eighty countries, are suffering water shortages.¹ Southern Africa has proved no exception to this global trend. According to the African Development Bank, "... *current calculations are that by 2000, South Africa will suffer water stress, Malawi will have moved into absolute water scarcity and Kenya will be facing the prospect of living beyond the present water barrier. By 2025, Mozambique, Tanzania and Zimbabwe will suffer water stress, Lesotho and South Africa will have moved into absolute water scarcity; and Malawi will have joined Kenya living beyond the present water barrier.*"²

The problems arising from scarce water resources are compounded by massive population growth. The world's population is expected to grow from 5,3 billion in 1990 to 6,2 billion in the year 2000, and to 8,5 billion in the year 2025.³ In Southern Africa, the annual population growth is expected to average 2,7 per cent over the next five years.⁴ Increasing population growth rates, within the context of dwindling fresh water resources, raises the prospect of competition for and armed conflict over shared water resources. This takes on ominous proportions if it is considered that, "[o]f the 200 first-order river systems, 150 are shared by 2 nations; and 50 by 10 nations all in all supporting approximately 40% of the world's population two-thirds of whom are located in developing countries."⁵

Indeed, conflict over scarce fresh water resources have already occurred. Consider here those

conflicts between:

- Turkey, Syria and Iraq around the waters of the Euphrates river;
- the dispute between Egypt and Ethiopia over the waters of the river Nile;
- the tensions concerning the sharing of the waters of the Colorado river between the United States and Mexico; and
- in Southern Africa over Zimbabwe's attempt to construct a dam on the Saabi river, thereby reducing the flow of the river downstream to Botswana.⁶

It is therefore imperative that the people of Southern Africa thoroughly comprehend the implications of the availability of fresh water resources in the region, and the relationship between this and the emerging 'new security' debate. It is in this context that this monograph is offered, aiming to act as a catalyst for further debate in the search for answers to these and other questions concerned with human security.

In the first article, Heidi Hudson provides a penetrating analysis of the interrelationship between water and security, and contextualises water scarcity within the theoretical confines of the new security agenda. This is followed by A Conley's lucid account of Southern Africa's water resources. Significant is Conley's conclusion that intensified rivalry and armed conflict need not be the only ways to manage this planet's water resources. He argues that regional co-operation could be the answer to this important issue. In this regard, he draws the attention to the fact that the first protocol in the SADC structure to be finalised is the **Protocol on Shared Watercourse Systems in the Southern African Development Community (SADC) Region**. It gives weight to the role of water the essence of life and prosperity in the lives of every living creature.

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RESOURCE-BASED CONFLICT: WATER (IN)SECURITY AND ITS STRATEGIC IMPLICATIONS

Dr Heidi Hudson

INTRODUCTION

Almost thirty years ago, Sills¹ argued that *"[w]ars have not arisen, as is sometimes said, from the struggle among peoples for the limited resources provided by nature. Even animals of the same species maintain their existence more by cooperation than by lethal struggle. Among men, with their greater capacity to relate means to ends, competition for economic resources, if not influenced by political loyalties and ambitions, ideological commitments, or psychological illusions, has led to cooperation in larger groups and larger areas."*

Sills displayed an immense faith in human reason that capacity that would make people co-operate when confronted by common problems, instead of fight. Yet, even after the demise of the Cold War, many societies remain insecure and unstable. Post-apartheid South Africa is a good example of how non-military destabilising factors, such as poverty and inequality, manifest themselves in a high crime rate and the influx of illegal immigrants. Beyond these human factors, other natural factors with the potential to generate serious conflict are at work. One of these is water. In an age where resources are rapidly diminishing and competition for resources has never been greater, environmental conflict is becoming more and more salient. While environmental and resource-based problems, such as acute water shortages, can heighten the potential for conflict, water is also the one natural resource where co-operative solutions in the name of survival seem most logical. In this area humankind's track record appears to be remarkably inconsistent.

Perhaps Sills' statement also suggests that, even though the resource dimension of international politics may be as old as international relations itself, conflict is more complex (and multi-dimensional) than a crude struggle over resources.²

The purpose of this article is to outline how security thinking in the post-Cold War era has widened to include the so-called 'soft' (non-military) sources of insecurity. Secondly, it aims to illustrate this broadening of the security agenda by focussing on resource-based conflict, with special reference to water security. The potency of water-based threats and reasons for co-operation and conflict will be highlighted. Thirdly, it reflects upon the implications of a new theoretical security framework for strategic studies as a discipline and for the role of the military in environmental conflict. Through highlighting resource conflicts in general and water threats specifically, the article presents a case for the redefinition of security in more holistic and non-military terms.

REDEFINING SECURITY: FROM STATE TO HUMAN SECURITY

In the new world order, the military concept of security is broadened horizontally to include political, social, economic and environmental aspects.³ Security now has to be treated as a holistic phenomenon.

In the 1970s, the concept of 'national security' was broadened to include international economics, when it became evident that the US economy was no longer the giant it had once been.⁴ Another noteworthy example was the report of the Palme Commission on Disarmament and Security Issues (1982), arguing that unilateral military action was no longer adequate to protect a state and its people. Global interdependencies in the technological age and common

problems which transcend national borders made the notion of 'common security' imperative.⁵

Buzan, in a seminal work published in 1991 ⁶, identified five 'sectors' of security, namely military, political, economic, social and environmental. 'Ecological security' particularly relevant to the context of this article is seen as the pursuit of human security through maintenance of the ecological support system. Buzan's typology serves as a useful analytical tool. His recognition of its interrelated nature, however, makes one aware of the mammoth task of implementing such a broad notion.

The days of classical-realist interpretations of (national) security as a politico-military struggle for power among states are over. The objects of security have evolved to include individuals, groups, regions and the global community.⁷ But notwithstanding the dramatic global changes, the state in practice still remains the primary referent in international politics. Given the fact that the state has often been (and still is) the root cause of insecurity among its people (as was the case in South Africa under apartheid), there is a real danger that regime or social *élite* security⁸ could remain the focal point of the dominant discourse. It is therefore imperative that the broadening of the security concept should challenge the *status quo*.⁹

External military threats to the sovereignty and territorial integrity of the state in the absence of Cold War tension have been replaced by non-military threats such as poverty, global inequality in the distribution of wealth between North and South, social injustice, human rights abuses¹⁰, oppression and ecological degradation. As long as states perpetuate social injustice, peace will remain a remote prospect and the state will remain vulnerable, because "[t]he true source of insecurity is the insecurity of people."¹¹

With this in mind, the objectives of security should be to pursue peace, democracy, development, social justice and environmental protection. 'Positive' peace, therefore, means more than just the absence of war ('negative' peace). A feminist reading of security takes it even further: discrimination and violence against women on a private level signify the absence of peace just as much as an undemocratic state system signifies a government at war against its own people.¹²

ENVIRONMENTAL SECURITY, RESOURCE-BASED CONFLICT AND WATER

There exists a clear conceptual link between expanding the concept of security to include environmental security and the inclusion of resource-based conflict as one of the main threats to the survival of humankind.

It is this conception that underpinned the report of the Independent Commission on International Development Issues (1980): "*Our survival depends not only on military balance but on global co-operation to ensure a sustainable biological environment and sustainable prosperity based on equitably shared resources.*"¹³ The June 1992 Earth Summit in Rio de Janeiro¹⁴ also made a significant contribution towards creating an awareness of the need for a reconceptualisation of security. However, the extent to which this consciousness has been translated into positive action remains questionable.

In the 1970s and 1980s, resource-based security problems revolved primarily around three issues, namely Middle Eastern oil, Soviet natural gas and Southern African strategic minerals.¹⁵ The 1990s were ushered in by a resource-based Gulf War (1990-91) an unequivocal demonstration of the US and the West's commitment to safeguard access to oil. The US Defence Department in a report in May 1995, outlined US "*enduring strategic interests*"¹⁶ in the

Middle East and predicted that the world would become ever more dependent on Gulf oil. Other examples of resource-based security problems include conflicts over

- land the Libyan-Chadian conflict over the Ozou strip;
- raw materials the Sudanese-Egyptian conflict over the Halayeb area;
- food ethnic conflicts in Africa; and
- fresh water (examples to be discussed later).¹⁷

Rogers¹⁸ predicts that four resources will be sources of possible future conflict:

- energy oil reserves in the Middle East;
- strategic minerals for instance in Central and Southern Africa, the High Andes, Amazonia and Eastern Asia;
- food reserves US and European Union grain surpluses; and
- water resources .

Mathews¹⁹ points out that the conventional distinction between non-renewable and renewable resources is paradoxical in nature: *"so-called nonrenewable resources such as coal, oil and minerals are in fact inexhaustible, while so-called renewable resources can be finite."* When non-renewable resources become scarce and more expensive, demand falls and alternative sources and technologies are explored. In contrast, the so-called renewable resources, such as water, fisheries, forests, soil and air are not unlimited: *"a fishery fished beyond a certain point will not recover, a species driven to extinction will not reappear, and eroded topsoil cannot be replaced (except over geological time)."*²⁰

The fundamental cause of resource depletion and degradation, namely that human beings consume resources faster than they can be replaced, emerges from this distinction. The ultimate effect of this is environmental scarcity. Three types can be identified:

- supply-induced scarcity which is caused by degradation and depletion of resources;
- demand-induced scarcity which could be the result of population growth or increased per capita consumption; and
- structural scarcity as a consequence of unequal distribution of resources within and between countries.

These three types of scarcity often occur simultaneously and interact.²¹ States are often guilty of not managing the natural resources in the best interest of their people, either by allowing exploitation by specific classes and a foreign *élite* and/or forcefully controlling access to resources by means of the military or bureaucracy.²² The situation can be exacerbated if scarcity impedes a state's ability to meet basic human needs. As a result the state may become repressive or more fragmented. Either way, the seeds of violent dissent are sown.

With regard to responses to such a situation of scarcity, two broad views emerge one optimistic (idealist) and the other pessimistic (realist).

The optimistic view has at its root the theory that common problems inevitably result in co-operation between states. It thus follows that the present environmental and related dangers can only be solved collectively.²³ (This view is also expressed in the opening quotation by Sills.) Ekins²⁴ summarises this perspective as follows: *"This is no zero-sum security. The health of a shared resource enriches both communities and threatens neither. Its abuse damages both."* Co-operation is therefore in everybody's interest. Water scarcity is the epitome of a common problem: rivers, watersheds and water pollution, for example, often transcend national boundaries. Consider the following: *"Nearly 50 countries on four continents have more than three-quarters of their land in international river basins; 214 river basins are multinational, while 13 are shared by five or more countries; and almost 40 per cent of humanity lives in an international river basin."*²⁵ It therefore follows that co-operation is built upon a clear mutuality of interest. The best known example of water co-operation in Southern Africa is that between Lesotho and South Africa in the form of the Lesotho Highlands Water Project aimed at supplying water to South Africa's industrial heartland.²⁶

The realist view is less optimistic. Solomon²⁷ points out that common problems will not necessarily lead to global co-operation. In fact, the World Commission on Environment and Development (WCED) has concluded that resource conflicts *"are likely to increase as these resources become scarcer and competition over them increases."*²⁸ Competitive behaviour takes many forms and varies in intensity.

Deliberate resource capture may occur as a form of preventive action when powerful groups within society anticipate future shortages²⁹, or resources may be captured for political or economic leverage.³⁰

Examples of resource capture can be found in three parts of the world where there are acute water shortages, namely in the Middle East, Africa and South Asia. Water not oil is the main source of conflict in the Middle East: *"long after oil runs out, water is likely to cause wars, cement peace, and make and break empires and alliances in the region, as it has for thousands of years."*³¹ Jordan and Syria's attempts to divert the Jordan river were one of the reasons why Israel went to war in 1967.³² During the 1967 Arab-Israeli war, Israel captured Syria's Baniyas river the last of the important Jordan headwaters not under Israel's control. They also succeeded in halting construction of a dam on the Yarmuk river.³³ Approximately forty per cent of Israel's groundwater originates in occupied territory, yet Arabs are not allowed to drill for water. Jewish settlers consume four times per head the water than Arabs do.³⁴ Relations between Turkey, Syria and Iraq are strained, since Turkey completed the Ataturk dam on the Euphrates river. The irrigation project has immense agricultural and hydro-electric benefits for Turkey³⁵, while Syria and Iraq are threatened by fertilisers, pesticides and salts that are transported downstream.³⁶ In Africa, the Nile water is a bone of contention between Egypt, Sudan and Ethiopia.³⁷ The Secretary-General of the United Nations, Dr Boutros Boutros-Ghali, warned in the mid-1980s that *"[t]he next war in our region will be over the waters of the Nile, not over politics ..."*³⁸ If the African Development Bank's predictions are correct, semi-arid Southern Africa has to prepare for intensified competition over water.³⁹ In Asia, disputes over water-use rights and river-diversion have been the cause of conflict in the river basins of the Mekong, which is shared by Laos, Thailand, Cambodia and Vietnam.⁴⁰

These examples of resource capture, either by diverting river flows, the construction of dams, large-scale irrigation projects or denying access to neighbours, clearly illustrate the link between politics and security. Upstream users yield formidable power over downstream users, who are vulnerable to a point where, in a cost-benefit analysis, violent forms of resolving the problem

may seem justified. The examples also provide concrete proof of the 'security dilemma': one state or actor's attempt to secure itself (eg. solving its own water problems) causing insecurity (here: water/food/economic insecurity) for its neighbours.

Resource capture could lead to ecological marginalisation. Weaker groups, denied access to resources, migrate to ecologically fragile regions that subsequently become ecologically degraded.⁴¹ Migrancy may also occur as a result of floods, droughts and rapid population growth that place a burden on already stretched resources. Ecological refugees may create room for further conflict over resources, that could lead to territorial disputes. Consider the case of India and Bangladesh and their dispute over the water of the Ganges river. Since 1975, India has been diverting most of the dry-season flow of the river to one of its internal rivers. This has had devastating effects on downstream Bangladeshi communities, who have had no alternative but to migrate to India. This, in turn, has led to highly politicised clashes between the local population and foreigners.⁴²

Water insecurity, coupled with underdevelopment, is a recipe for conflict. Some of the contributing factors are lack of technological sophistication, unprofitable use of resources and a lack of formal agreements to regulate water rights and usage. Unlike the case of Israel, where a desert area has been turned into agricultural land due to the availability of technology, Africa lacks the scientific, technological and financial resources for ecological conservation.⁴³ In India, *"irrigation uses 360 times as much water as industry."*⁴⁴ Irrigation is not only the cause of immense wastage, but also contributes to the salinisation of farm land.⁴⁵ Ethiopia has never joined Egypt and Sudan in a legal agreement to regulate water use and water rights of the Nile⁴⁶, and has stubbornly refused to acknowledge that water is a shared resource.

Along with a broadening of the security agenda should come the recognition that resource use, as well as conflicts over resource use, involve a multiplicity of stakeholders inter- and intrastate (state and non-state) actors at local, national, regional, continental and global level.⁴⁷

This article has so far argued for a widening of the security concept to include all aspects that affect human security. But the concept 'environmental security' may in itself pose a threat, because the so-called 'securitisation' of the environment can *"restrict the range of means available for resolving environmental problems."*⁴⁸ Are we not putting security issues back into the hands of the militarists? Are we perhaps 'softening' security at the risk of 'hardening' environmental issues?

SINK OR SWIM: QUO VADIS STRATEGIC STUDIES?

Buzan argues that strategic studies should be a subfield of security studies. Since strategic studies scholars and strategists have *"well-defined specialist expertise"*⁴⁹ in military matters, it automatically defines the parameters of their role in the overall scheme of things. To broaden the strategic agenda would imply an unnecessary duplication of existing expertise in the non-military spheres and it would also stunt and skew the development of strategic studies itself. Strategists would also be tempted to bias their work in favour of the military. They should therefore stick to what they are good at.

The author does not share this view. While it is agreed that strategic studies should form part of a broad discipline of security studies (perhaps on equal footing with peace studies), it is imperative that it is recast as a matter of survival. Strategic thinking in the words of Kuhn should make a paradigm shift, and be reshaped to accommodate the broader non-military security agenda.⁵⁰ This would imply the adoption of a new body of knowledge and a radical and critical

reshaping of its military tenets, thus discarding its preoccupation with power and state-centric goals and military means.⁵¹ The makeover need not be too painful, as the 1980s have already witnessed a convergence of idealist and realist agendas (as embodied by the principle of 'common security') and a subsequent synergy between strategic studies and peace studies, both having had to broaden their scope.⁵² After all, the end of the Cold War has not convinced the world that deterrence (military security) has succeeded. In its aftermath practical/human security remains as elusive as ever. The military's appalling track record in Southern Africa is indicative of its failure to bring about 'positive peace'.

The broadening of the security agenda, to some extent, was formalised in 1992, when the International Institute for Strategic Studies changed the focus of their mission statement from the military to a promotion of "*the study and discussion of and the exchange of information upon any major security issues including without limitation those of a political, strategic, economic, social or ecological nature.*"⁵³

Orthodox strategists' complaints about the unmanageability of a broad security agenda should be seen in the light of an attempt to keep strategic studies in the hands of the military. But how representative is this view? The fact that some of the basic assumptions of strategic studies are being questioned from within the strategic community itself many of the critics being former military staff members⁵⁴ is proof that the pragmatic and common sense ('realistic', not 'realist') nature of strategists in general will prevail. Exposing the security agenda would contribute towards making security less secretive⁵⁵, which in turn would increase the probability of reaching consensus between state and non-state actors around common security issues.

What specific contribution can strategists make to the current security debate and praxis?

MISSION IMPOSSIBLE?

Many questions regarding the role of the military in environmental conflict still need to be fully explored. For instance, do national security policies adequately reflect the nature of non-military sources of insecurity? What are the implications of these policies for the role of the armed forces? Are the armed forces "*properly trained for the demands of the new global security agenda?*"⁵⁶

Consider the case of South Africa. While recognising the rising saliency of non-military problems in the region, as well as their transnational nature⁵⁷, the **Draft White Paper on National Defence** makes it clear that the primary mission of the South African National Defence Force (SANDF) is to defend the country against external military aggression.⁵⁸ The size, design, structure and budget of the SANDF will therefore be determined mainly by its primary mission. Activities, such as "*disaster relief, provision of emergency services; search and rescue; evacuation of South African citizens from high threat areas; efforts to curtail cross-border crime; protection of maritime and other natural resources; socio-economic upliftment; and regional defence co-operation*"⁵⁹ are secondary functions. They are motivated by the following: "*Extensive use of a defence force in non-military activities is economically inefficient; it contributes to the militarisation of civil society; and it undermines the preparedness and capabilities of the force with respect to its primary mission ...*"⁶⁰ Training priorities for the SANDF are

- the preparation of the armed forces for defending the country against external aggression;
- the standardisation of procedures following the integration of the various statutory and

non-statutory armed forces; and

- the development of the political and ethical dimensions of military professionalism in a democratic context.⁶¹

Whereas it is agreed that socio-political and economic solutions to the problems of instability, underdevelopment, rising crime rates, illegal immigrants and ecological degradation are more desirable than military ones, the above orientation does raise serious questions about the SANDF's preparedness if, for instance, competition over scarce water resources turns into armed conflict.

Strategists' talent to relate means to ends must be harnessed and given an application beyond purely military matters. It means that a change in 'ends' (from absence of war and the protection of the *status quo*, to the pursuit of social change and justice) necessitates a change in 'means' from military to non-military methods of conflict resolution and prevention. The military's function should therefore be to collaborate on (not control) the implementation of policies.

But what does this mean on a concrete level? What role can strategists play in the water-security dilemma? Dependence on water cannot be solved by shifting to other sources, increasing production, recycling resources and taxing people to reduce consumption. But there are ways to reduce vulnerability. Stock-piling (preventive measures), crisis management, diplomacy and the use of the military to secure access to resources are some of the options available.⁶² Even though the military instrument can never be entirely dismissed as an option, it undoubtedly represents the least favoured for the 21st century.

In order to address resource-based conflict, strategists and policy-makers alike first need to familiarise themselves with the broad range of accumulating problems and then develop a systematic understanding of the interrelationship between these problems (for example, environmental and resource-based security cannot be seen in isolation from non-environmental issues, such as drug and arms trafficking and refugees). On a practical level, such an insight must manifest itself in, for instance, a systematic way of predicting whether and when conflict will occur if resources continue to be depleted. Frameworks, in the form of early warning systems, need to be developed to determine these conditions. It is wrong to assume that conflict is inevitable, but considerable attention needs to be devoted to the development of non-violent methods of conflict resolution appropriate to the nature of the conflict, the resource involved and the local peculiarities. However, the complex interdependent character of non-military conflicts can impede the application of generalised solutions. Grassroots organisations should therefore play a vital role in informing other stakeholders about local conditions. Broad civil participation would reduce the chances of the military gaining control over the management of environmental conflicts.

CONCLUSION

This article has argued that positive peace becomes unattainable without an expanded understanding of security. Inclusion of the environmental debate on the security agenda is therefore imperative to prevent the already intense competition over scarce resources from spiralling out of control. The assumption that common problems necessarily lead to common solutions needs to be revisited in the light of the potency of conflict over water resources.

The purpose of the article was to examine the nature of resource-based problems as part of the global security agenda, rather than to offer definitive solutions. Yet, a number of issues that

should be debated further has been raised. The role of strategic studies, and the position of strategists and the armed forces in a redefined security arena, have been explored. A case has been made for the retention of strategic expertise, provided that it is reshaped to meet the challenges of a redefined security agenda. Civilian control and participation could help to safeguard environmental concerns against being 'securitised'.

As a fledgling democracy, South Africa will have to consider these issues seriously. Clarifying the role of the armed forces with regard to environmental security does not only have implications for its own people, but for the region as a whole.

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A SYNOPTIC VIEW OF WATER RESOURCES IN SOUTHERN AFRICA

Al Conley

INTRODUCTION

This article reviews the vast variation in water availability and development across the watershed areas of Southern Africa. Natural conditions range from semi-arid to abundant, but relative prosperity in the region tends to be inversely proportional to water availability. Some observations are made regarding possibilities for enhancing prosperity and reducing the risk of disasters, without compromising the autonomy of the various nations, through trade and other forms of regional water-related collaboration.

While the southern tip of Africa is semi-arid, the availability of water increases rapidly towards the Equator. The Zambezi River carries more than ten times as much water, and the Zaire River carries more than a hundred times as much water as the Orange River in the south. Yet, despite its increasing water scarcity and poor land resources, the south has a highly developed economy. In contrast, comparative economic progress lags northward amidst abundant, but under-utilised, resources. Despite the risks of drought, when contemplating Southern Africa dispassionately as a unit without artificial borders, the conclusion seems inescapable that it would be logical to promote enterprise in the less-developed northern regions where the abundance of natural resources is more amenable.

But how can the desire of nations to retain autonomy over their own destinies be safeguarded within such an obvious need for interdependence? How can the various peoples who have thrown off colonial yokes ensure that they benefit fairly from collaborative development of their own resources, particularly with stronger partners?



Map: Water courses of Southern Africa

(Click on the map for an enlargement)

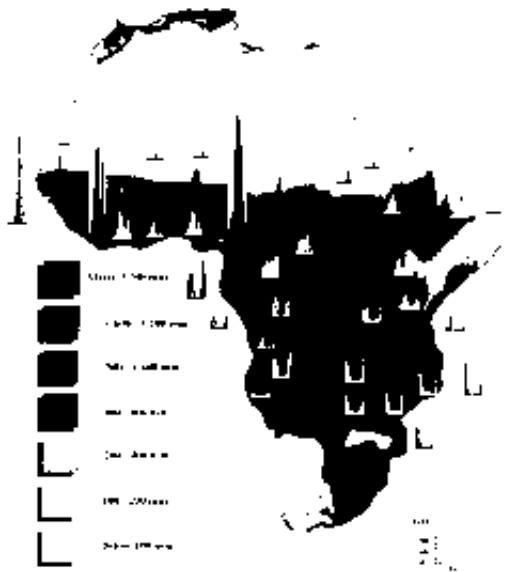
Does a part of the answer to establishing low-risk partnerships not perhaps lie in voluntary associations of the type which are provided by free trade (where alliances that the parties wish to maintain depend on controllable factors such as market competitiveness), rather than in bureaucratic arrangements? Is the time not ripe in post-colonial Southern Africa for emancipated nations to develop each other's potential through economic sense? With sufficient determination to demonstrate solidarity to the outside world, will evident success in achieving competent self-reliance not also stimulate donor and investor confidence, particularly if good returns can be demonstrated?

According to a USAID Report of 1995¹, "*[n]inety percent of the surface water used in southern Africa goes to irrigation. The economies of many of the nations are based upon agriculture, and increased development of irrigation is often seen as the key to economic growth. Currently, there are about 1 813 000 hectares irrigated in the SADC region, and there are approximately 6 900 000 additional hectares available for irrigation. That is, only about 20 percent of the irrigation potential has been developed.*"

South Africa at present represents an example of a country which has reached a stage in its development where its scarce water resources will have to be allocated increasingly to the most worthwhile purposes only. It has become necessary for each water use to warrant the cost of providing the water. In this respect, South Africa's returns on agricultural production per unit of water give comparatively low returns for high consumption. While South Africa has neither the weather nor the soil to make it an ideal country for agricultural expansion, some of the more northern countries have sufficient water and land and could welcome additional economic opportunities. Most of their territories fall within a summer rainfall area, which could initially reduce the need for the storage capacity which will ultimately be needed to stabilise irrigation. Being freed from the need for agricultural self-sufficiency which its period of isolation imposed, it could make economic sense for South Africa to satisfy its increasing needs for agricultural products from the open market, while employing its water to better advantage. As a result of their proximity to South Africa, the northern countries are well placed to engage in voluntary trade.

World-wide attention on the sustainable exploitation of resources, pollution control and

conservation has found expression in the concept of integrated catchment management, in which the employment of resources is considered holistically, using the whole catchment, or an integration of its sub-catchments, as the management unit. Central to this approach are the relationships between land use and water. A key success factor will be the close involvement of affected people. With good technology and discipline, improvements in agriculture advance nations to a high agrarian and industrialised level. In this respect, the south has industrial, commercial, financial and other infrastructures and entrepreneurial skills with which to link hands with all peoples in the region. For every nation involved, a policy of economic collaboration will also logically need to embrace the value of trade with the rest of the world.



Map: Mean Annual Rainfall in Africa and Monthly Distribution

(Click on the map for an enlargement)

PHYSIOGRAPHY AND CLIMATE

A plateau with an average elevation of 1 200 metres is the main topographical feature of Southern Africa. Most of Angola, Botswana, Lesotho, Namibia, South Africa, Swaziland, Zambia and Zimbabwe are situated on it. Northern Angola and most of Zaire lie in the Zaire basin, while Malawi and Tanzania are dominated by the Great Rift System. Most of Mozambique lies on coastal lowlands.

- **Angola:** The country, which lies mainly on the plateau, consists of hilly grasslands in the central interior, with rocky deserts in the south and tropical forests in the north. The plateau drops sharply to a narrow coastal plain.
- **Botswana:** This country's elevation on the plateau averages 1 010 metres. The terrain is flat or gently rolling, but hilly to the east. Forests are found in parts of the north. Almost all of the central and south-west areas are covered by the Kalahari desert.
- **Lesotho:** Most of this country is steeply mountainous, rising to over 3 400 metres from the plateau, although there are plains to the west.
- **Malawi:** The landscape is dominated by the Great Rift Valley which runs from north to south throughout the country. The vegetation is mostly grassland and Savannah which

rises steeply to the west of the plateau.

- Mozambique: Flat plains extend inland from the coast. The land rises steadily west of the coastal plain to the mountains and plateau escarpment along the west border. Sand dunes and swamps line the coast. Much of the country is covered by grasslands and tropical forests.
- Namibia: Namibia is dominated by the Namib desert along its west coast and the Kalahari desert to the east. Most of the interior is rolling plain associated with the plateau.
- South Africa: Most of the interior of the country lies on the plateau, which is separated from the eastern coastal strip by an escarpment. The Cape mountains dominate the south of the country. The Namib desert borders the west coast and the Kalahari desert lies to the north.
- Swaziland: The west border is characterised by mountainous pine forests. East of the mountains are rolling grasslands which transform to low grass and brush covered plains further east. Mountains rise along the eastern border.
- Tanzania: The country is characterised by many mountains and lakes associated with the Great Rift Valley. The coastal lowlands are 15 to 65 kilometres wide.
- Zaire: The north is characterised by tropical rainforests with Savannah grassland to the south. Highlands are located on the east and south-east borders. The topography is dominated by the basin of the Zaire River.
- Zambia: This country has mostly flat lands associated with the plateau.
- Zimbabwe: This country has mostly high rolling topography associated with the plateau.

Africa south of the Equator varies in climate from tropical rainforest in the north to desert in the south-west. The climates not only vary from north to south, but also from east to west. In the former case, the long periods of overhead sun in the north encourages warm tropical rainfall in two rainy seasons, whereas the cooler southern Cape relies on the passages of winter cold fronts. In the latter case, the warm Agulhas sea current of the Indian Ocean favours rainfall along the eastern regions, whereas the cold Benguela current in the Atlantic Ocean supports desert conditions along the west coast, south of the tropics. The mountainous escarpments that extend from north to south encourage, but also distort rainfall systems, whereas the western seaboard is desert outside the tropics. The map shows the mean annual distribution of rainfall. In general, the summers receive the most rainfall. In the Southern African Development Community (SADC) region seven per cent of the area is desert with less than 100mm of rain per year, fifteen per cent is arid with 100-400mm per year, sixteen per cent is semi-arid with 400-600mm per year, nineteen per cent is dry sub-humid with 600 - 1 200mm per year, forty per cent is moist sub-humid with 1 200-1 500mm per year and three per cent humid with more than 1 500mm per year.

The rainfall in Southern Africa originates largely from the Indian Ocean, although several weather systems combine to form the rainfall patterns. Rainfall is seasonal throughout most of the region. As illustrated, in many areas a five to seven month wet season occurs during the summer when virtually all of the annual rainfall occurs. These rainfall patterns, especially the long dry season, affect agricultural and grazing practices. Much of the region is subject to

unpredictable droughts, of which those in the 1980s and 1990s have been particularly severe.



Map: Drought Risk in Africa
(Click on the map for an enlargement)

PROJECT AREA CLIMATE CONDITIONS

Country	Climate	Annual Precipitation (mm)
Angola	North and central - tropical Extreme south - semi arid	1 000 to 1 500 50
Botswana	North and east - semi arid Southwest - desert (Kalahari Desert)	300 to 560 Negligible
Lesotho	Mild highland climate	710
Malawi	Lowlands - hot, humid, tropical Plateau - cooler tropical	1 800 to 760 North to south
Mozambique	Tropical	400 to 1 200
Namibia	North - semi arid South - desert	200 to 500 30 to 150
South Africa	Mild semi arid with pockets of subtropical and desert	1 000 - east coast Generally less than 600 Negligible in deserts
Swaziland	Tropical	500 to 1 900 east to west
Tanzania	Tropical	400 to 1 400
Zaire	North - tropical wet South - tropical wet and dry season	200 940 to 1 200
Zambia	Tropical	1 300 - north 500 to 750 - south
Zimbabwe	Northeast - tropical Southwest - semi arid	1 300 - east 400 - west

Source: Stanley Consultants, Inc.

REGIONAL WATER SUMMARY

The rainfall over Southern Africa generally increases northward towards the Equator, with the more northerly river basins having a much higher runoff per unit area than those in the south. For example, unit runoffs for the Orange, Zambezi and Zaire basins are about 12mm, 90mm and 300mm respectively. Many rivers in the drier zones of the region are seasonal, only flowing when sufficient rainfall occurs and ceasing to flow for part of the year. Some may flow only after abnormally heavy rain, once in several years. The Zambezi River appears to have a long term

high and low-flow cycle, and is currently in a low flow period.

The following table from Pitman² summarises the natural water resources of each river basin. The Mean Annual Run (MAR) figures do not represent the available yield of the river. In Southern Africa, with its variable flow regimes and high evaporation losses, probably only two thirds of the MAR is available as yield.

River	Area km ²	MAP mm	MAR 106M ³ /annum	Net surplus/deficit
Orange	973 000	330	11 860	Deficit
Limpopo	413 000	520	7 330	Deficit
Save	104 000	680	6 200	Surplus
Okavango	586 000	580	11 650	Surplus
Cunene	117 000	830	5 550	Surplus
Zambezi	1 234 000	860	110 000	Surplus
Rovuma	155 000	1 100	28 000	Surplus
Zaire	3 981 000	1 500 (est.)	1 250 000	Surplus

Source: Pitman

In addition, a report by the African Development Bank³ gives the following statistics on water availability and consumption by state.

State	Renewable water resources		Annual usage		
	Total 106m ³	1990 per capita m ³ /a	Year of data	Usage 106m ³ /a	Per capita usage m ³ /a
South Africa	50 000	1 420	1990	19 040	540
Lesotho	4 000	2 250	1987	50	34
Swaziland	7 000	8 820	n/av	n/av	n/av
Namibia	9 000	240	n/av	n/av	n/av
Botswana	9 000	780	1980	90	98
Zimbabwe	23 000	2 370	1987	1 220	129
Mozambique	58 000	3 700	1987	760	53
Angola	158 000	15 770	1987	480	43
Zambia	96 000	11 350	1970	160	86
Malawi	9 000	1 070	1987	160	22
Tanzania	76 000	2 780	1970	480	36

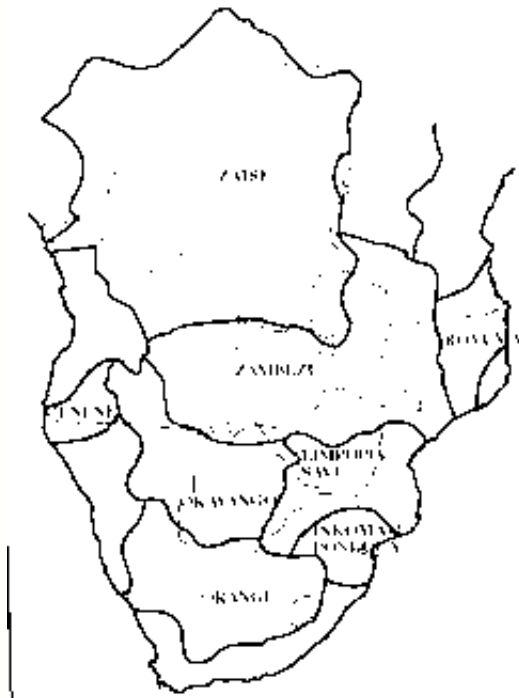
Source: Pitman



Map: Southern African River Systems

(Click on the map for an enlargement)

This table shows that, while South Africa accounts for more than eighty per cent of the total regional water use, only ten per cent of the total water resource is available in South Africa.



Map: Main River Basins of Southern Africa

(Click on the map for an enlargement)

The northernmost basin - the Zaire - has a water resource potential that dwarfs all rivers to the south. The MAR is over ten times that of the Zambezi and of the order of 100 times that of the Orange or Okavango. The hydropower potential at Inga is an enormous 45 000 MW - more than sufficient to meet the present electricity demand for the whole of Southern Africa

SURFACE WATER IN THE MAIN RIVER BASINS

Orange River Basin

The Orange River flows westward from Lesotho through South Africa to the Atlantic Ocean. Its main tributary is the Vaal River. For its last 450 kilometres, the Orange River forms the border between Namibia and South Africa. In very wet years, a portion of Botswana also contributes runoff to the Molopo, a tributary of the Orange. However, the Molopo is blocked by sand dunes and does not contribute to the flow in the main stem of the Orange.

The Orange River is highly developed. Its water will soon be fully committed and further opportunities for development are limited. The economic and industrial heartland of South Africa, the Gauteng area, lies partially within the northern part of the catchment. The Vaal River is augmented by the Sterkfontein Dam which was built high up to store water pumped across the divide from the Tugela River which flows eastward to the Indian Ocean. Water apportionment in the Vaal River system, which connects eight drainage basins, is managed with very sophisticated statistical modelling techniques.

River and state	Area km ²	Inc. MAR 106m ³ /a	MAP mm	Total storage 106m ³	Storage as % of total MAR	Topo-graphy	Populat-ion in millions 1990	Populat-ion in millions 2020
Orange								
Lesotho	30 000	4750	800	-	-	Steep	1.75	3.46
South Africa	380 000	2240	280	9 507	136	Undul	0.58*	1.17*
Botswana	103 000	negl.	350	-	-	Flat	small	small
Namibia	264 000	470	150	383	81	Undul	small	small
Vaal								
South Africa	196 000	4 300	570	8 182	190	Undul	10.71**	22.43**
Total	973 000	11 760	330	18 072	154		13.0**	27.1**

Source: Pitman

* Based on population of towns - error should be small as rural population is small.

** Population of PWV area supplied by Vaal system - includes users within Crocodile tributary of Limpopo basin.

Increasing demands in the Gauteng area have required the construction of the Lesotho Highlands Water Scheme, whereby water will be re-routed under gravity from dams in the upper reaches of the Senqu River (the Orange River in Lesotho) to the Vaal Dam catchment, instead of flowing directly to the Orange River. Its initial phase is under construction.



Irrigation is well developed in the South African portion of the Orange basin. The Orange River Project consists of large dams, tunnels and canals. It supplies urban users and irrigated areas along the Orange River, as well as irrigation and urban users situated outside the basin in the Eastern Cape *via* long tunnels.

Little water resource development has occurred in the Botswana portion of the catchment, as these rivers flow only in years of good rainfall.

In Namibia, two dams have been built to supply irrigators on the Fish River at the lower end of the basin. There are also three dams on the Nossob tributary of the Molopo, which is also within the Orange River basin.

There is a net deficit of water in the Orange River basin. As the Vaal River system is heavily over-utilised, the Gauteng region relies on a transfer of $611 \times 10^6 \text{ m}^3/\text{annum}$ of water from the Tugela River. The natural resources of the Orange/Vaal basin are also supplemented by a transfer of $78 \times 10^6 \text{ m}^3/\text{annum}$ from the Usutu basin. In the Vaal basin, much of the water returns to the rivers as treated effluent which is available to downstream users. Diffuse and point-source pollution in the industrialised Gauteng region has raised salinity levels in its middle and lower reaches. Eutrophication is also a problem in its middle and lower reaches. Salinity is not serious in the remainder of the Orange River basin, but some areas experience high sediment yields.

Upstream developments have greatly modified the flow regime in the lower reaches of the Orange and at the mouth. In particular, the nature of the releases from hydropower generation at the Gariep and Vanderkloof dams has led to the proliferation of pest species of blackfly. The high utilisation of water in the Orange River catchment implies that any further development will have a negative impact on the flows and the natural environment of the lower reaches and the mouth of the river.

Namibia has expressed interest in obtaining more water from the Orange River, but no definite proposals have been made. Botswana would like Orange River water, but their rights are not

clear. The biggest constraint to improved linkages is the availability of water, as the river is already almost fully committed. For transfers to Namibia, the large losses experienced in the lower Orange River would have to be taken into account

Limpopo River Basin

The Limpopo River is formed by the confluence of the Crocodile and Marico rivers on the South Africa/Botswana border. It flows east, forming the borders between South Africa and Botswana, then South Africa and Zimbabwe, and then flows through Mozambique to the Indian Ocean. In Mozambique it is joined by its largest tributary, the Olifants River, of which the basin is mainly in South Africa.

Most of its tributaries are well developed. In Botswana, four of the five major dams are on the fully developed Notwane River and the fifth on the Shashe River. In South Africa, the upper portions of all the major tributaries except the Matlabas, the Lephalala and the Sand rivers have large dams. In Zimbabwe, a 400 x 106m³ dam has been proposed on the Tuli River, a tributary of the well-developed Shashe basin. In Mozambique, the Massingir Dam on the Olifants River is being repaired after being damaged in the civil war. There is little scope for further development on the Olifants River in Mozambique, as its tributaries are almost fully developed in South Africa. While the Limpopo itself has no major dams, two sites have been investigated on the South Africa/Botswana stretch, and a site for an 11 000 x 106m³ dam was identified by Mozambique in 1971, slightly downstream of the Zimbabwe/South Africa border.

The natural resources of the Limpopo/Olifants basin are also supplemented by transfers from other South African river basins, 500 and 227 x 106m³/annum originating from the Vaal and Komati/Usutu River basins respectively.

In this basin, the transferred water is employed mainly for domestic, industrial and power station use. A significant percentage of this water finds its way back to the rivers as treated effluent and is available to downstream users.

Of the four states making up the Limpopo basin, South Africa has the highest population density. This is due in large part to the highly urbanised Gauteng area situated partially within the catchment in the south.

Actual values of Zimbabwe's demands within the Limpopo basin are not available. However, the largest category of water use within the basin is irrigation. Cattle and game ranching are also practised in areas of lower rainfall in the south. The main urban user in the basin is Bulawayo, which is supplied from dams in the upper reaches of the Limpopo tributaries. Bulawayo has fully developed nearby sources in the Limpopo and is likely to look north to the Zambezi basin for further water supplies.

River and state	Area km ²	Inc. MAR 106m ³ /a	MAP mm	Total storage 106m ³	Storage as % of total MAR	Topo- graphy	Populat- ion in millions 1990	Populat- ion in millions 2020
LIMPOPO								
Botswana	87 000	420	450	248	59	Flat	5.98	9.88
South Africa	110 000	2 200	530	1 001	46	Undul	0.77 +Shashe	1.49 +Shashe

Zimbabwe	63 000	1 160	515	687	59	Undul	1.39*	2.90
Mozambique	74 000	850	500	-	-	Flat	?	?
OLIFANTS TRIBUTARY								
South Africa	73 000	2 650	620	1 239	478	Undul	3.66	7.73
Mozambique	6 000	50	500	2 844	105	Flat		
	413 000	7 330	520	6 019	82		11.80+	22.00+

Source: Pitman

* Based on population of towns - error should be small as rural population is small.

** Population of PWV area supplied by Vaal systems - includes users within Crocodile tributary of Limpopo basin.

In South Africa, there is a net shortage of water in the Crocodile catchment which is augmented by purified sewage effluent from the Vaal River. This constitutes a major source of water for downstream users, mostly irrigators, with associated water quality problems. While Botswana does not yet have a water shortage, no surplus is available for export. In Zimbabwe there is more irrigatable land than water available. It has been suggested that water be transferred into the Mwenezi tributary of the Limpopo from the surplus in the Save River basin, but this may not be financially viable for irrigation.

The Luvuvhu, Letaba and Olifants rivers, which are major tributaries of the Limpopo, traverse South Africa's Kruger National Park. Their intensive utilisation has reduced flows to the extent that the once perennial Luvuvhu and Letaba Rivers now cease for several months in the dry season. While less badly affected by upstream utilisation, the Olifants River now carries such a high sediment load that it threatens to silt up its natural pools, which are important to riverine eco-systems. In the subsistence farming areas of Zimbabwe, overgrazing is also causing erosion and silt loads. Low flows have also resulted in saline intrusion upstream of the Limpopo River mouth in Mozambique.

Seepage from coal mines in the upper catchment of South Africa's Olifants River, the largest tributary of the Limpopo, has elevated salinity levels and given rise to highly acidic waters in certain areas. In the central regions of the Olifants River basin, overgrazing has caused severe soil erosion and heavy silt loads in the Olifants River.



A Joint Limpopo Basin Committee exists, consisting of representatives of South Africa and Botswana. Zimbabwe has been invited to join. Joint Permanent Technical Committees (JPTCs) exist between South Africa and Botswana, and South Africa and Mozambique. A contract existed between the old Bophuthatswana Water Supply Authority, South Africa's Department of Water Affairs and Forestry and Botswana's Water Utilities Corporation regarding transfers from Molatedi Dam on the Marico River to Botswana.

The main stem of the Limpopo River is the international border between South Africa and the three neighbouring states of Botswana, Zimbabwe, and Mozambique. Currently, utilisation of the flow in the Limpopo River is restricted to surface abstractions from numerous small weirs or withdrawals from alluvial aquifers in or adjacent to the main river channel. These sources serve to supply water to a number of large irrigation undertakings on both sides of the river, to a few settlements and towns, and to certain mining operations. Farmers from South Africa and Botswana who have built weirs in the Limpopo must apply via the JPTC to both Botswana and South Africa and must ask neighbouring farmers for permission to increase abstractions from the Limpopo. An agreement exists regarding a medium sized dam on the Ramaguebane tributary of the Shashe River, on the Botswana/Zimbabwe border, which serves communities in both states.

A formal agreement was signed in 1971 between South Africa and the old Portuguese government of Mozambique. It provided for the building of the Massingir Dam on the Olifants River thirty kilometres downstream of the South African/Mozambique border. It placed no restrictions on South Africa's water use, and recognised that the flow at Massingir Dam would decrease as more storage was built in South Africa.

There is a Limpopo Basin Permanent Technical Commission for the four countries which may serve as a forum for co-operation and planning.

The only existing international transfer concerns an amount of $7,3 \times 10^6 \text{ m}^3/\text{annum}$ from the Molatedi Dam on the Marico River to Botswana. This water is used to supply the urban demands of Gaborone. While this amount was agreed upon in the treaty, the capacity of the

pipeline is 9 x 106m³/annum and provision was made in the treaty for South Africa or the old Bophuthatswana to sell their share of the Molatedi allocation on an annual basis.

Both South Africa and Botswana abstract water from the Limpopo for irrigation, South Africa more than Botswana. A dam on a tributary of the Shashe River serves both Botswana and Zimbabwe.

Transfers of eutrophic water from South Africa could potentially cause water weed or hyacinth problems. Botswana is extremely sensitive about this issue and controls water weeds and hyacinth vigorously to prevent them gaining a foothold in the Okavango swamps or other nature reserves.

As an internationally shared resource, any future large scale utilisation of the Limpopo River will require extensive collaboration by South Africa and the three affected neighbouring countries. Adequate future water resources planning in both the Upper and Middle Limpopo River will require improved hydrological monitoring, an improved understanding of the interaction of surface flows and groundwater in alluvial aquifers adjacent to the river, and an improved understanding of transmission losses and a hydrological modelling capability to generate plausible flow sequences for different development scenarios.

Although Zimbabwe sees a potential for increased irrigation along the river, this is not a major river for the country, as it receives only two per cent of the national MAR. There are plans in Botswana for a dam on the Lower Sashi River, a tributary of the Limpopo, to supplement water supply to Gaborone. This dam would probably have a substantial impact on the quantity and quality of water in the Limpopo River.

The Limpopo is close to being fully committed by the upstream states, who also need to consider Mozambique.

Cunene River Basin

After rising in the central Angolan highlands, the Cunene River flows south to the Namibian border, then west to the Atlantic Ocean, forming the border between Angola and Namibia.



Angola has four major dams on the Cunene River, three built primarily for hydroelectric power. The power generated at the Matala and Ruacana Dams, which have a potential capacity of 280 MW, is used in Angola and Namibia. The Calueque Dam had to be abandoned during construction in 1975. This incomplete dam has a 2,2m³/second capacity pump station which supplies water to 600 000 people for domestic use, stock-watering and irrigation in Ovamboland in Namibia (in the Cuvelai basin, which drains into the Etosha Pan) outside the Cunene River basin. The fourth dam, for generating hydropower at Gove, was damaged during the Angolan civil war. This also put irrigation schemes at Matala and Calueque in Angola out of operation. With the loss of regulation at Calueque Dam upstream of Ruacana, power can only be generated from run-of-river flow. At present, the 240 MW run-of-river power station at Ruacana periodically has to reduce or cease production during low flows, but when the upstream waterworks are restored, continuous operation will be possible. In Namibia, the tributaries of the Cunene are non-perennial, with flow generally only reaching the Cunene in years of good rainfall. No major dams or schemes have been built on them. A fifth dam, for hydropower generation, is planned on the Namibia-Angola border downstream of the other dams and of the Epupa Falls, primarily to supply Namibia with power. With a capacity of 7 300 x 10⁶m³ it will be the third largest dam in Southern Africa. The Epupa Dam would improve the utilisation of the Cunene's hydropower potential and meet Namibia's energy needs for the early part of the next century.

River portion	Area km ²	Inc. MAR 10 ⁶ m ³ /a	MAP mm	Total storage 10 ⁶ m ³	Storage as % of total	MAR Topography
Cunene						
Angola	104 000	5 500	900	3 140	57	Undul
Namibia	13 000	50	250	-	-	Steep
Total	117 000	5 500	830	3 140	57	

Source: Pitman

The Namibian portion of the basin is very sparsely populated. The extent of the present Angolan

population within the basin is uncertain. There were once 3 000 hectares of irrigation under Matala Dam in Angola, which went out of production many years ago during the hostilities.

The Cunene basin has a water surplus at present and experiences no major water quality problems. The biggest constraint to interstate linkages has been the Angolan civil war. In future planning, no major negative impacts are foreseen, as long as provision is made for the water requirements of the estuary.

A JPTC between Angola and Namibia deals with concerns about the Cunene River basin. It is considering the improvement of the Calueque Dam to allow an increased abstraction by Namibia, beyond the previously agreed maximum of 6m³/second.

Zambezi River Basin

The Zambezi is the largest river south of Zaire. After rising in eastern Angola, it flows south through Zambia to its border with Namibia. It then flows generally eastwards, forming the borders between Zambia and Namibia, and Zambia and Zimbabwe, before traversing Mozambique to the Indian Ocean. Parts of eight Southern African countries, namely Namibia, Angola, Botswana, Zambia, Zimbabwe, Tanzania, Malawi and Mozambique are associated with its basin, which has not been developed to nearly its full potential.



Irrigation, mainly in Zambia, Zimbabwe and Mozambique, is by far the largest water user and is likely to remain so in the foreseeable future. Their areas total 5 000, 60 000 and 10 000 hectares respectively, and all have high potential for expansion, reportedly 200 000, 210 000 and 230 000 hectares respectively.

Power generation is also an important user. A major proportion of the region's electricity of some 10 000 MW is generated at four hydroelectric schemes in the catchment. Some 4 500 MW is generated at Kariba and Cahora Bassa dams (in Zambia/Zimbabwe and Mozambique respectively), and at Kafue Gorge and Nkula stations on its tributaries of Kafue and Shire Rivers in Zambia and Malawi, respectively. In addition, thermal power stations in Zimbabwe are cooled

by water from the catchment. The possibility of constructing a 181 metre high gravity arch dam with a capacity of 1 680 x 106m³ to produce 1 600 MW on the Zambezi River at Batoka Gorge fifty kilometres downstream of Victoria Falls between Zambia and Zimbabwe has also been under consideration as an alternative to more plants which use fossil fuels and cause air pollution. However, while Zimbabwe requires an increased supply of electric power, Zambia has excess generating capacity, as well as several alternative sites for hydropower generation, some of which are for plants in remote areas which can utilise smaller streams and reduce transmission costs. Beyond Zambia's concern about the environmental impact of the Batoka Gorge scheme, the reservoir would also require the relocation of people who were moved to Batoka Gorge for the construction of Kariba Dam.

State	Area km ²	Inc. MAR 106m ³ /a	MAP mm	Total storage 106m ³	Storage % of total MAR	Topo- graphy	Populat- ion in millions 1990	Populat- ion in millions 2020	Demand 106m ³ /a 1990	Demand 106m ³ /a 2020
Angola	127 000	20 000	1 300	-	-	Undul	0.08	0.20	1 000	2 500
Zambia	580 000	52 000	800	?	?	Undul	7.50	16.80	4 000	10 000
Namibia	5 000	-1 000**	680	-	-	Flat	0.06	0.14	negble	400
Botswana	23 000	-5 000**	690	-	-	Flat	small	small	negble	500
Zimbabwe	230 000	17 000	700	3 900	23	Undul	6.60	13.79	6 000	15 000
<i>Kariba Dam*</i>				180 600	430					
Tanzania	30 000	5 000	1 200	-	-	Steep	2.20	5.41	negble	800
Malawi	90 000	16 000	1 100	-	-	Steep	9.50	21.47	500	2 700
Mozambique	149 000	6 000	800	63 000	57	U-F	?***	?***	200	5 500
TOTAL	1 234 000	110 000	860	247 500+			25.94+	57.8+	11 700	37 400

Source: Pitman

* Kariba Dam is situated on the Zambezi River between Zambia and Zimbabwe

** Net loss

*** The size of the population in the aftermath of the civil war in Mozambique is uncertain.

The importance of fishing is also increasing, particularly in Lakes Kariba and Cahora Bassa and along the Kafue River. Notwithstanding that the three large dams (Kariba, Cahora Bassa and Kafue), and numerous others in the catchment, are said to have negative effects on the migration of fish (as none have fish ladders), it is estimated that more than 120 000 tons of fish per year are harvested in the Zambezi River basin. Similarly, 48 000 and 54 000 tons come from Lake Malawi/Nyasa-Shire River system, and from Zambia, respectively.

A water transport sector is also active in the Zambezi basin, particularly in Lake Malawi/Nyasa where more than 200 000 passengers and 50 000 tons of cargo are transported each year. While the Zambezi River is navigable in its lower reaches, the draft of the craft is very limited.

Lake Kariba meets the modest transport requirements of the local population where road links are inadequate and expensive. Although tourist boats use Lake Kariba upstream of the Victoria Falls and the Chobe, no major water transport linkages between states are envisaged.

All of Malawi's and most of Zambia's and Zimbabwe's main industries are situated within the catchment. Although industrial water usage is relatively small, it could grow substantially over the next twenty to thirty years. Primary water usage by the population is small compared to the Zambezi's yield, although this will grow.

The Zambezi River is attractive for eco-tourism, centred mainly on the Victoria Falls and Lake Kariba. Tourism is a major industry, as much of the area near the main river is rich in wildlife, particularly in Zambia, Botswana and Zimbabwe. Unfortunately, overgrazing and erosion in the Zambezi valley in Zambia, Zimbabwe and Mozambique, have a negative effect on the environment.

At present there are no major water quality problems in the Zambezi, although pollution occurs near the larger centres of Zambia and Zimbabwe. Coming mainly from industries, the larger industrial concerns are gradually redressing the situation. Another source of pollution is the densely populated city of Chitungwiza (near Harare), while the city of Tete in Mozambique also discharges most of its effluent into the river. Although water pollution has not yet caused regional conflicts, the potential exists. Mining and industrial activities in the Lake Malawi/Nyasa catchment, particularly oil fields in Malawi and Mozambique, uranium deposits in Malawi, iron deposits in Tanzania, and development of pulp industries in Malawi, may pollute the lake unless regional environmental considerations form part of their planning and development.

A vast amount of water is lost from the large dams through evaporation. About $5\,000 \times 10^6 \text{ m}^3/\text{annum}$ is lost from Kariba and $3\,000 \times 10^6 \text{ m}^3/\text{annum}$ is lost from Cahora Bassa. Water also evaporates from the natural lakes and wetlands, such as Lake Malawi, but this has been allowed for in the MARs quoted in the table. Although a certain flow will be required for hydroelectric power generation, there is a substantial water surplus in the Zambezi basin. It is estimated that by the year 2020 only 34 per cent of the flow will be utilised. While any extraction of water upstream of the hydroelectric schemes will reduce the flows available for power generation and the maintenance of the natural environment and its features, any resulting dependence on increased thermal power generation, with the associated environmental costs would have to be weighed against the benefits.

The Zambezi basin has been studied by SADC as a pilot exercise to promote the integrated environmentally sound planning and management of Southern Africa's international river basins. Previously, the main constraints had been inadequate inter-state communication and co-ordination in view of a perceived need for self-sufficiency. Water resource development and management of the Zambezi were accordingly dominated by national single purpose projects. These developments rarely emphasised the interests of other riparian countries, or their environmental impact.

The Zambezi River Action Plan (ZACPLAN) is accordingly a programme by the Zambezi River basin states to develop a management plan to ensure that the shared resources are utilised in a manner that guarantees maximum long term advantage to all. It is intended to address the concerns of all parties by treating the entire basin as one development unit in a manner which will minimise user and environmental conflicts among riparian countries and seek maximum and sustained benefits from water resource developments. The strategy is to create mathematical models to analyse development and management alternatives from which an indicative

integrated plan for the development and management of the water resources of the Zambezi River basin can be devised. The simulation models will be used to assess the adequacy and feasibility (in terms of quantity and quality of water resources and environmental impact) of developments, as well as to deal with real time forecasting of water levels, river flows, and/or water quality, for operation and management of reservoirs and lakes, water level monitoring, etc., as part of water management and flood and drought warning and mitigation. The administrative, institutional, investment and technical structures and capacities at national and regional levels will also have to be strengthened to ensure sustainability in the implementation and updating of the plan.

The Caprivi Strip is a 450 kilometre extension of land at the north-east corner of Namibia to give it access to the Zambezi River. The southern border of the Caprivi Strip forms a portion of Namibia's international border with Botswana, north of the Okavango Delta. The Chobe River, which partially bounds the Caprivi Strip to the south, flows out of the Linyanti Swamps into the Zambezi River. Angola and Zambia border the Caprivi Strip to the north, and Zimbabwe just touches the Strip at its eastern end. The Caprivi Strip, and the Chobe River area in particular, have significant areas of wetlands. There are extensive natural and wildlife resources throughout the area. A potential exists for developing the land and water resources.

The Zambezi and Shire River flow regimes in the floodplain are complex and interrelated because of the Shire River's low gradient over the last 200 kilometres (with only a ten to fifteen metre drop) before joining the Zambezi River. The floods are worse when both Zambezi and Shire Rivers are flooded and may last several weeks, with the Shire River backing up 150 to 200 kilometres, creating at least 1 000 km² total flooded area. The low flow characteristics of the lower Zambezi and Shire Rivers create similar challenges.

Okavango River Basin

The Okavango River forms the largest endoreic river system in Southern Africa. Approximately 11 billion m³ of water evaporates each year in swamps, lakes and salt pans in north-eastern Botswana. Most of the flow originates in Angola where the Okavango River rises. The Okavango, (or Rio Cubango in Angola) rises in the southern Angolan highlands, flows south-east for 650 kilometres to Namibia, where it forms the border for 350 kilometres before turning more southerly, crosses the Caprivi Strip (a distance of 60 kilometres), and enters Botswana. Here it flows 100 kilometres, then into the Okavango Delta and dissipates.

The main tributary, the Rio Cuito, also rises in southern Angola and joins the Okavango on the Namibian Border seventy kilometres upstream of where the river crosses the Caprivi Strip. The active catchment area of the two rivers, almost entirely within Angola, is about 120 000 km². The delta covers some 5 000 km². The area annually flooded by the Okavango varies from season to season. Inflow to the delta averages 10 000 million m³ per year, with the rate varying from an average of 650m³/seconds in April to about 150m³/seconds in November. There are extensive floodplains in Angola along the Cuito, and a permanent swamp at the confluence of the rivers. Outflow from the Delta, along the Boteti River, is less than three per cent of the inflow. The Boteti River enters a second swamp - the Mopipi - and when the flow is sufficient, the water level rises to spill first into Lake Xau and then into the Makgadikgadi pans. These pans, with an area of about 12 000 km², constitute the terminal sink of the Okavango.

The Okavango basin can be divided into three geographic zones. The first is in Angola, extending to within fifty kilometres of the Namibian border, where many tributaries running in narrow gorges contribute to the main flow. Little is known about the population in this area

because of the civil war in Angola. The middle zone consists of the border river, flowing in a narrow alluvial plain up to six kilometres wide and thirty to seventy metres below the general level of the bush savannah, leading to the somewhat shallower and wider panhandle. Some 100 000 people gain their livelihood from the river and its associated wetlands in this zone on the Namibian side, with an unknown number on the Angolan side. This population is increasing naturally at three per cent per annum, and the area offers one of the few opportunities for settlement in Namibia. Thirdly, Ngamiland in Botswana has a population of about 90 000, with around 25 000 in the delta itself, even more dependent upon Okavango water.

No major water schemes appear to have been built in Angola. Namibia abstracts water from the Okavango River at Rundu, on the Angolan border. The Namibian Eastern National Water Carrier is under construction to link Rundu with Windhoek. The remainder of the river basin has remained largely undeveloped.

A Southern Okavango Integrated Water Development Project has been investigated with the main objective of securing more reliable supplies for existing and potential water users on the southern peripheries of the Okavango Delta without harming the environment. The supplies were intended for irrigators, urban users, a mine, livestock and rural communities. Although the project was not recommended for construction, as groundwater and other supplies appeared more economical and less of an environmental threat to the Okavango Delta, it is still of interest to Botswana.

River and state	Area km2	Inc. MAR 106m3/a	MAP mm	Total storage 106m3	Storage as % of total MAR	Topography
Okavango - upstream delta						
Angola	163 000	10 800	900	-	-	*
Namibia	99 000	200	450	-	-	Flat
Botswana	2 000	negl.	550	-	-	Flat
Total	264 000	11 000	730	-	-	
Okavango - total						
Angola	163 000	10 800	900	-	-	*
Namibia	173 000	350	450	-	-	Flat
Zimbabwe	20 000	50	500	-	-	Flat
Botswana	230 000	450	450	-	-	Flat
Total	586 000	11 650	580	-	-	

Source: Pitman

* Flat to undulating

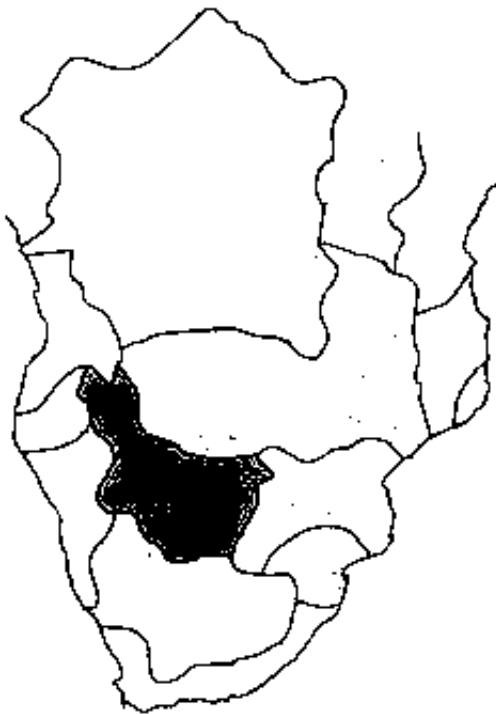
While no data is available on population, the basin as a whole is probably very sparsely populated.

Relative to present demands, there is a vast surplus of water in the Okavango River basin. However, any plans for using Okavango water would have to take into account the environmental requirements of the delta. The eco-system sustained by the Okavango River contains a wealth of wildlife fauna and flora, probably unrivalled in Africa, and any long term developments should be wisely planned to ensure preservation of the system as wilderness

areas and wildlife sanctuaries. It is believed that transferring large quantities of water out of the catchment of any of the swamps within the basin could impact negatively on the environment. Organisations such as Greenpeace International have actively opposed plans to use the water of the Okavango elsewhere in Botswana and would need to be contended with if developments were planned.

There are no existing or proposed international water transfers and no inter-state water resource linkages to other sectors. The construction of works to use the water of the Okavango would be difficult. The channels, comprising the delta, silt up endlessly and change course, which would impede the life of any development.

Bids for exploitation of the delta waters in Botswana begin with the water supply for Maun, irrigated agriculture along the edges of the delta, and industrial use at the Orapa diamond mine some 250 kilometres to the south-east of the delta. Proposals have been made to transfer water to Francistown, Gaborone, and further. In Namibia there are less detailed proposals for irrigation along the river banks, and a study is underway to quantify the demand from central Namibia for supplies *via* the Eastern National Water Carrier. There are reported to be plans for irrigation developments in the Angolan watershed, which is suffering from deforestation. These unco-ordinated proposals have not been integrated into a basin programme. Their impact on the environment is uncertain, but a change of habitat will affect the balance of species. These effects will first be felt in the delta.



The management of environmental changes will require an ecological understanding of the Okavango basin

The management of environmental changes will require an ecological understanding of the basin, particularly the dynamics of the wetlands and the interdependence of all their life forms. This will apply mostly to the border reach of the Okavango and the delta. In the upper active catchment the concerns will centre mainly on hydrology, land use, irrigation and siltation risks from deforestation. Another issue for discussion is water rights.

The choice between development and conservation measures is complex, involving political,

social, and economic factors. A resource management programme by suitable institutes which would produce broadly acceptable environmental changes would have to set the Okavango options in the wider social and economic needs of the riparian states.

Owing to the lack of development in the catchment, the Okavango River does not appear to have water quality problems.

In 1990, Botswana and Namibia signed an agreement forming the Joint Permanent Water Committee (JPWC) on water resources of mutual interest. In September 1994, an agreement was signed between Angola, Namibia and Botswana, forming the Permanent Okavango River Basin Water Commission (OKACOM). It acts as technical advisor to the three member countries with respect to the use, management and development of the Okavango River.

Save River Basin

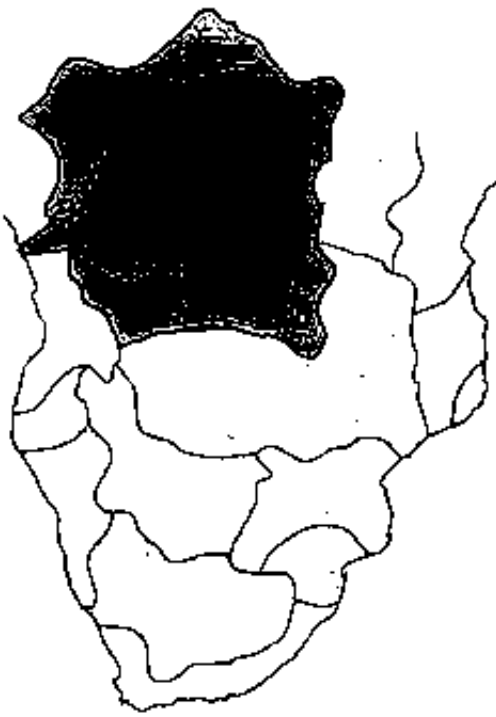
The Save River rises in central Zimbabwe and flows south-east for 360 kilometres before entering Mozambique and flowing east for 350 kilometres to the Indian Ocean some 150 kilometres south of Beira. The east bank of the middle and lower Save has some of Zimbabwe's largest commercial irrigation estates. There are ten major dams in the catchment and another dam may be constructed in the near future.

Twenty per cent of the surface water in Mozambique comes from Zimbabwe in the Save River. There has been little development in the Mozambique portion of the basin.

State	Area km ²	Inc. MAR 106m ³ /a	MAP mm	Total storage 106m ³	Storage as % of total MAR	Topo- graphy	Popu- lation in millions 1990	Popu- lation in millions 2020
Zimbabwe	85 000	6 000	700	3 900	65	Undul	2.66	5.55
Mozambique	19 000	200	600	-	-	Flat	0.10*	
Total	104 000	6 200	680	3 900	63		2.76	

Source: Pitman

* 1960 information



Twenty per cent of the surface water in Mozambique comes from Zimbabwe's Save River

The Save River basin supports the highest density of rural population in Zimbabwe. There are no reliable figures for population in Mozambique, which has been severely affected by the civil war, but this portion of the basin is relatively lightly populated.

The irrigation demand in Zimbabwe will be $975 \times 10^6 \text{ m}^3/\text{annum}$ once the present irrigation schemes have been fully developed. In Mozambique 400 hectares of irrigation were originally developed, but only 150 hectares are being utilised at present

Projections of water demands until 2020 are not available. However, the pattern is likely to remain similar to the present one. Further storage will be constructed and large scale irrigation is likely. Primary urban and industrial demands are small at present, but will increase. While the Save basin within Zimbabwe has large resources of low grade coal which may be developed, the associated demand will be small in relation to the overall resources of the basin.

Close to $1\,000 \times 10^6 \text{ m}^3/\text{annum}$ has been committed to irrigation. However, it is estimated that a potential yield of more than $3\,000 \times 10^6 \text{ m}^3/\text{annum}$ would be available if dam sites were developed. Unless Zimbabwe plans large expansions, a surplus of water exists in the basin. Over eighty per cent of the water of the Save lies in Zimbabwe, which plans to utilise it to its full potential in that country. Mozambique could be compensated by releases from Zimbabwe.

The Save River valley is the most densely populated rural area of Zimbabwe and the catchment are subject to erosion and siltation. If large new dams should require the resettlement of many people, this would raise social issues. The position of the Gona-Re-Zhou National Park within the Zimbabwean basin along the Mozambique border would also have to be considered.

Irrigation along the Save River in Mozambique would have to avoid salinity problems on the schemes and downstream.

There are no treaties dealing with water from this basin, no water resource transfers between

states, no inter-state water resource linkages and no known proposals for water transfers between states.

Rovuma River Basin

The Rovuma River rises in northern Mozambique and flows north to the Mozambique/Tanzania border and then east to the Indian Ocean, forming the border between Mozambique and Tanzania. Although little information is readily available on the Rovuma River, little development is believed to have taken place in the catchment.

State	Area km2	Inc. MAR 106m3/a	MAP mm	Total storage 106m3	Storage as % of total MAR	Topo- graphy
Mozambique	101 000	18 000	1 100	-	-	U-F
Tanzania	54 000	10 000	1 100	-	-	U-F
Total	155 000	28 000	1 100	-	-	

Source: Pitman

No population figures are available. Originally 400 hectares were developed within the basin. Only 220 hectares are at present utilised, and a huge surplus of water exists in this basin.

The Rovuma is situated in an area of high rainfall with little water resource development. If the flows to Mozambique of the water resources of the Save and Limpopo basins diminish with upstream use, the Rovuma could be an important resource for development in the various sectors for the northern provinces of Mozambique.

Zaire River Basin

The Zaire/Congo River rises in south-eastern Zaire and flows in a wide arc north, then south-west to the Atlantic Ocean. For the last about 120 kilometres before it reaches the sea, it forms the border between Zaire and Angola. Other countries with significant portions lying partially within the basin are Cameroon, the Central African Republic and the Republic of Congo.

River	Area k2	MAR 106m3/a	MAP mm
Congo/Zaire	3 981 000	1 250 000	1 500 (very roughly)

The basin is largely undeveloped and has a vast surplus of water. The MAR is estimated at 1 250 000 x 106m3, which is more than ten times that of the Zambezi and about 25 times the total MAR of all South Africa's rivers.

It has an enormous hydroelectric power potential. The Inga rapids, some thirty kilometres upstream of the Angolan border in Zaire, represent the largest single hydroelectric energy potential in the world. Power of 400 TWh/year can potentially be generated at Inga (equivalent to approximately 45 000 MW). This would be sufficient to supply the present electricity demands of the whole of Southern Africa.

Inkomati River Basin

The entire Inkomati River basin covers nearly 50 000 km2, of which 63 per cent is in South Africa, five per cent in Swaziland, and 32 per cent in Mozambique. It assumes the name

Inkomati in Mozambique where it is formed by the confluence of the Komati and Crocodile Rivers. Other tributaries include the Lomati and Sabie Rivers which originate in South Africa, and the Uanetze, Massintonto, Mazim'chopes, and Bobole. The middle and lower portions of the Inkomati basin lie in flat alluvial plains and are subject to recurrent floods. Annual flows vary greatly. The average annual flow at the Mozambique/South African border from 1952 to 1989 was $2\,025 \times 10^6 \text{ m}^3$, with the minimum flow only $28 \times 10^6 \text{ m}^3$ (1982/83), and the maximum $4\,926 \times 10^6 \text{ m}^3$ (1954/55). Monthly river flows also vary greatly, with more than half of the average annual discharge occurring in January, February, and March. There are clear indications that the natural flows in the dry season have been greatly reduced through abstractions.

Abstractions in South Africa and Swaziland amount to about $1\,400 \times 10^6 \text{ m}^3/\text{year}$, about one third of the original flows at the Mozambique border. The 22 large dams in the catchment have a combined capacity of about $360 \times 10^6 \text{ m}^3/\text{year}$ in the Komati/Lomati/Crocodile catchment, and $40 \times 10^6 \text{ m}^3/\text{year}$ on the Sabie River. Two further dams are being developed, namely the Driekoppies in South Africa, and the Maguga in Swaziland. Mozambique has a single large dam, the Corumana, completed in 1988, and proposes to build two more, the Moamba and Chuali. Their main purpose is irrigation, although small hydropower plants are incorporated in some of the designs.

There are large populations in the under-developed sections of the basin. A JPTC was set up between Swaziland and South Africa in the early 1980s to discuss developments in the Komati basin. Outline plans for developing the basin were prepared in some detail, and a draft agreement for water sharing was drawn up in 1986.

In 1982, a Tripartite Permanent Technical Commission (TPTC) was established with representatives from Mozambique, South Africa, and Swaziland. This committee is working towards an agreement on the sharing of water resources between the three countries. There is also an agreement between South Africa and Swaziland for a binational agency, the Komati Basin Water Authority (KOBWA), to implement the joint development of the Driekoppies and Maguga dams and to operate them. A separate treaty provides for setting up a Joint Water Commission (JWC) to take over the functions of the JPTC.

Pongola/Maputo River Basin

The Pongola River rises in eastern South Africa. It flows east for about 200 kilometres, passing just south of the Swaziland border, then turns north and soon enters Mozambique where it is known as the Maputo River. The river flows into the sea at the southern side of Maputo Bay. The Ngwavuma and Usuto Rivers, two large tributaries which drain much of southern Swaziland, join the Pongola/Maputo River near the South Africa/Mozambique border.



The Maputo River is a very important source of water for the population in the southern part of Mozambique. At present, a large share of the river flow is diverted by users in South Africa and Swaziland, and flows are much reduced compared to previous years. Mozambique is very concerned that, as more water is diverted from the river, it could impair the quality of life for the local population, through reduced flows and degraded water quality. Negotiations are underway between the three countries to attend to the problem.

GROUNDWATER

As groundwater is found almost everywhere in Africa, shallow wells are a main water source for many people in the region. With modern technology to locate and exploit groundwater, there is an even greater potential to utilise it better. As surface water in the region becomes fully committed, pressures to utilise groundwater for domestic, municipal, industrial, and irrigation uses will increase. The development of groundwater therefore should be carefully managed to protect its quality and to guard against over-utilisation of the aquifers. Development of this water resource may be local or international, according to the location and extent of each aquifer.

Southern Africa has four major aquifer systems:

- The Precambrian crystalline basement rock forms the continental mass outcrops in a 100 to 300 kilometres wide band inland from the Atlantic coast in Zaire, Angola, Namibia, and South Africa. They cover most of the area of Tanzania, Malawi, and Zimbabwe.
- Sedimentary formations overlie the depressed basement in the axial part of the continent, including the Zaire, Okavango, and Kalahari basins. The Karroo fossil basin, in a vast raised plateau, consists of fairly coarse sandstones which are good aquifers. The sand and sandstone formations of the Kalahari can also provide good aquifers.
- The vast basalt effusions are especially situated in the Rift Valley zone, Malawi and Tanzania, and in South Africa and Botswana.

- The sedimentary coastal basins vary greatly in size. The narrow Gabon basin which covers the west coast from Angola to the Cape, contrasts with the vast Tanzania/Mozambique basin which varies in width. In these basins sandstone, sand, and limestone strata form large aquifers, which are sometimes artesian.

Geology and climatic conditions determine the available amount of groundwater. The recharge capacity of the aquifers, which is often the limiting factor for development, depends on the rainfall and infiltration rates over the contributing catchment. Three main climatic factors that affect infiltration are: the annual rainfall, its time of occurrence, and the rate of evapotranspiration. Sometimes a single factor can have a decisive influence. Wherever the rainfall exceeds about 1 200mm per year, the decisive factor is the amount of the rainfall. Where the rainfall is below 250mm, the intensity of the precipitation is important. In arid areas most of the annual precipitation can fall within a few hours, exceeding the daily potential evapotranspiration. If it persists over several days, it gives the water time to infiltrate and recharge local aquifers in particular cases. In the Steppe and dry Savannah regions with rainfall between 250mm and 1 000mm, the potential evapotranspiration is the decisive factor, for the rainfall is spread over a longer time. During the rainy season, which can vary greatly from one year to the next, the potential evapotranspiration can still have a large value. However, a highly variable remainder is almost always available for runoff and infiltration. During the dry season, which can last from three to six months, some regions of Africa have climatic conditions of the semi-arid or arid type, while receiving more annual rainfall than some countries in the wet temperature zone of Europe. During the dry season, the evaporation effect can be considerable in surface and shallow aquifers.

The biggest yields are provided by clay-free alluviums, continental or marine Cretaceous sandstones, and Karstic limestones. Most of the groundwater is acceptable for human consumption and livestock. In general terms, with respect to its quality, which depends on the geology, climate, and geographical situation, the following would apply:

- In arid zones, groundwater usually has a calcium/magnesium bicarbonate character at the upstream regions where the runoff infiltrates. It then acquires a higher sulphate content and increased amounts of chlorine and sodium at the end of the watercourse in the regions where high evaporation acts directly on shallow aquifers.
- Some geological formations, especially of Permian-Triassic or Cretaceous age and lagoon origin, contain mineral salts which dissolve in the groundwater, particularly in Mozambique.
- In the coastal sedimentary basins, which are often composed of permeable formations, pumping can result in contamination by sea-water intrusion.
- In the Precambrian basement rock in tropical rain country, the water is usually not highly mineralised or aggressive.

Groundwater development has tended to be difficult. The best aquifers are often in arid or even desert zones which receive little or no recharge from rainfall. Good aquifers in coastal zones are subject to deep seawater intrusion. In contrast, unsuitable rock formations are sometimes found in rainy tropical zones. Groundwater prospecting, drilling and well-digging tend to be difficult and expensive owing to the weakness of the infrastructures, unfavourable natural conditions, remoteness, the wide dispersal of villages, and a lack of equipment, qualified personnel, project-uptake facilities, and investment and maintenance funds. Villagers and herdsman may also lack

the technical capacity and material resources to maintain pumps. Nevertheless, substantial progress has been made in relatively cheap and effective methods of prospecting, computerisation of data and inventories, grassroots motivation, education of villagers, and the creation of African water-drilling enterprises.

Although Precambrian crystalline basement and other strongly cemented rocks of low permeability underlie much of Southern Africa, recent experience has shown that with good well site selection practices and appropriate well designs, such strata can often sustain yields between one and five litres per second, which is sufficient for small irrigation systems.

INTERNATIONAL CO-OPERATION: SADC

The first Southern African Development Co-ordination Conference (SADCC) was held in 1979 to harmonise regional development plans and to reduce the region's economic dependence on South Africa. In August 1992, its ten member countries (Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, Swaziland, Tanzania, Zambia and Zimbabwe) signed a treaty establishing the Southern African Development Community (SADC), which replaced SADCC. South Africa became a member in 1994. The Treaty establishing the SADC, which came into effect in October 1993, declares the following aims:

- deeper economic co-operation and integration, on the basis of balance, equality and mutual benefit, providing for cross-border investment and trade, and freer movement of factors of production, goods and services across national boundaries;
- common economic, political and social values and systems, enhancing enterprise, competitiveness, democracy and good governance, respect for the rule of law and human rights, popular participation, and the alleviation of poverty; and
- strengthened regional solidarity, peace and security, in order for the people of the region to live and work in harmony.

Protocol on Shared Watercourse Systems in the SADC region

It is significant that the first protocol in the SADC structure which has reached finality concerns water - the essence of life and prosperity. It is the culmination of several years of work by the Environmental Land Management Sector of SADC and represents an important milestone in the region's resolve to take its future into its own hands and to lay the foundations for developing its own resources. As water, well managed, can be a cause of peace rather than conflict, this protocol will hopefully prove to be an example to the world of how to deal with water issues peacefully in the interests of people who cannot live without it.

The protocol lays a foundation, in the form of a regional convention for wresting the greatest sustainable good for the largest number of people from the region's resources. It affirms a commitment by the signatory states to the principle of equity, provides agreed procedures for applying the principle in practice, and serves to structure orderly binational and multinational relations on shared watercourses. It enjoins governments to order their relations regarding particular shared watercourses by way of agreements which would provide for the establishment and functioning of particular institutions in respect of such watercourses and their agreed powers and duties to fit particular circumstances. As such, it can pave the way for international development agencies to assist with the orderly development of regional water resources. The protocol is in line with the development of international law world-wide, being in consonance

with the draft Convention on the Non-navigational Uses of International River Systems being formulated by the UN and caters for the settlement of disputes. It enjoins member states to:

- respect and apply the existing rules of international law and abide by the principles of equitable utilisation;
- maintain a proper balance between resource development and conservation and enhancement of the environment to promote sustainable development;
- pursue and establish close co-operation in the study and execution of all projects;
- exchange available information on such watercourse systems;
- use shared watercourse systems in an equitable manner and protect them adequately;
- require any person intending to use the water for purposes other than domestic use, or intending to discharge all types of wastes into such waters, first to obtain a permit from the authority within the state concerned;
- notify without delay other potentially affected states of any emergency originating within their respective territories;
- take all measures necessary to prevent the introduction of alien aquatic species;
- maintain and protect shared watercourse systems to prevent pollution or environmental degradation; and
- establish appropriate institutions for effective implementation of the protocol, for which a monitoring unit will be established under SADC, and the formation of river basin management institutions will be encouraged.

By mid-November 1995, the protocol had been signed by all the member countries, except Angola and Zambia.

For the protocol to function properly, existing water legislation must be taken into account, to eliminate conflicts in the utilisation and development of the regional river basins. A need for training in legal expertise has been identified.

Regional collaboration through free trade

The value of promoting trade as a means of building regional prosperity, and of the potential new role of South Africa in particular, is emphasised by the following sentiments expressed in the State of Food and Agriculture report of the Food and Agricultural Organization of the UN for 1994.⁴

"The conclusion of the Uruguay Round of GATT negotiations and the subsequent signing of the Uruguay Round Agreement was a major event in 1993. An important aspect of the Uruguay Round Agreement for Africa is the reduction in the value of the numerous trade preferences that Africa currently receives from developed countries.

The process of democratization and integration of South Africa in the world, regional and

subregional economic systems following the abolition of the apartheid system was intensified in 1993. The sheer size of the country and its advanced stage of economic and technological development means that its moving away from isolation may have a significant economic impact on the economies of the subregion. While South Africa accounts for 17.6 percent of the total area occupied by the ten SADC countries plus South Africa itself, its population is about 30 percent of the total and its GNP about 4.8 times that of all the SADC countries combined.

The ongoing efforts at trade liberalisation are likely to change the modalities and institutions of economic cooperation in the subregion. Under the existing patterns of trade, domestic trade policies and regional institutions, the incorporation of South Africa in a regional trading arrangement in southern Africa will not have a large impact. However, liberal domestic and trade policies, including a shift from self-sufficiency to more open policies in South Africa, may result in significant changes in competitiveness with South Africa exporting more manufactured goods to the countries in the region and importing more agricultural products. In such a case, a form of a welfare-increasing, net trade-creating arrangement may emerge. Moreover, South Africa is expected to phase out production subsidies, resulting in diminishing exportable surpluses unless corresponding improvements in productivity are achieved.

In agriculture, opportunities exist for the coordination of research on plant and animal disease control. As South Africa is the country with the most advanced agricultural research system, it could become the centre of agricultural research and training activity for the area. A regional agency could be established to coordinate the research carried out by national research centres and universities."

Further sentiments in support of the value of trade were expressed in South Africa's Financial Mail of 27 October 1995.⁶

"There are obvious advantages in our becoming part of an Indian Ocean Rim trade bloc. Among the core group countries - India, Singapore, Kenya, Mauritius, SA, Oman and Australia - there are identifiable interests, unity of thought, confluence of size and levels of development that favour the encouragement of free trade through market-friendly policies that have been applied voluntarily.

SA's gross national product accounts for more than 40% of sub-Saharan Africa's and it's generally accepted that SA's economic future is inextricably tied up with those of its neighbours. If our economy strengthens steadily while theirs don't, their people will continue flocking to SA.

SA exports much more to the rest of sub-Saharan Africa than it buys from these countries. Last year, our exports to Zimbabwe, Mozambique, Zambia, Kenya and Malawi (our main trading partners in Africa) were, at R6,3bn, almost five times as much as our imports from them. That can be explained partly by the removal of sanctions but also because SA manufactures are substantially cheaper and more suited to these markets than similar ones from the industrial West. Another factor is the inability of African countries to supply SA competitively and appropriately. The continuation of such a huge trade imbalance already has some people talking about neo-colonialism. Yet the best hope of regional upliftment lies in deploying SA skills and capital through southern Africa. SA business has an affinity with Africa, a familiarity with the way it thinks and operates, that could see it in time take the lead in development, at least in southern Africa.

There has been a substantial harmonisation of macro-economic and other policies in the region (urged by the IMF on reluctant governments) which has led to greater trade liberalisation. SA

Reserve Bank Governor Chris Stals was asked early this year by his fellow central bank governors in the region to draw up a financial protocol. Among its aims are guidelines for cross-border investment.

The key to the support of the politicians of southern Africa for a southern African free trade area probably lies in putting forward a convincing argument that the whole sum of the resources of the region is worth more than the parts. Moreover, if it can be demonstrated that a prosperous southern African trade bloc could achieve even greater prosperity from participation in an Indian Ocean Rim bloc, political opposition might become more muted. A few Southern African Development Community members already qualify as members of the mooted Indian Ocean Rim trade bloc. That grouping could eventually comprise 22 member states, stretching as far eastward as Malaysia and Australia and offering a total population of 1,5bn people, a third of whom are urbanised, with all that implies for the development of skills and a market for consumer durables and industrial equipment. But even before such a bloc becomes a reality, there is the lure of India. Though a poor country of 950m people, it has enjoyed the benefits of economic reform in recent years that have seen the real incomes of hundreds of millions of employees soar. The market they present is regarded as one of the world's most exciting and southern and eastern Africa have a link with it through Indian communities.

These are markets that most of the countries of southern Africa, except SA, are just too small, feeble and poor to exploit on their own. Their prosperity lies only in some form of alliance. And the degree to which this realisation can be turned into reality depends on SA's diplomatic ability to mitigate their fears of loss of political sovereignty and convince them of the material benefits offered in return."

In addition, Prof J A Allen⁶ of the School for Oriental and African Studies of the University of London has expressed the following thoughts on the efficient international allocation of water as a scarce economic resource:

"It is food production which requires very high water volumes and dry regions of the world such as the Middle East have for the past twenty years been meeting their water deficits by importing water in food.

The conversion of water into food for a national population is the dominant element in a national water budget. The task is to spread the awareness of the real costs of delivering water to all sectors in relation to the social and economic returns gained from the use of such water. A number of essential ideas have to be emphasised. For example that scarce water may underpin more sustainable livelihoods in non-agricultural sectors than in the agricultural sector itself; and, secondly, that scarce water should rarely be exported in low value products, and scarce and expensive water should never be exported in low value products such as food staples and animal fodder.

In water scarce regions, rational economic measures are the substitution for water through gaining access to the cheapest water available, namely the water in food imports. Such rational political behavior augers well for the future of water allocation and management globally and very powerfully counters the intuition of those who argue for irreversible escalation of tension and even military conflicts over water.

Another very important contextual issue is the shift in approach of key international players in the allocation and management of water. For example, the engineering professionals in the major international lending and development agencies such as the World Bank, as recently as

1991 found it impossible to recognise that economic principles should inform water allocation and management policies.

If policy makers have the awareness, freedom and capacity to address the full range of factors affecting water allocation and management they will prevent the all too common situation where resource users are doing the wrong thing very efficiently, which is usually worse than doing the right thing a little badly. For example it is economically and even socially inappropriate to allocate expensive water to crop production where the value of the output per hectare is less than the cost of delivering water to that hectare. It is far better to provide livelihoods in other sectors where the returns to water are positive and sustainable.

Wise governments will be looking at their food demand futures and relating them to their water potential and determining what proportion if any of their future water will arrive in food imports. Just as important will be the analysis of future global demands and the impacts of such demands on the price of food.

At the local, national and international levels there is a poor understanding of the global complementarity of strategic resources such as water. There is an urgent need for policy makers to recognise the relative significance of water in the major water-using economic sectors and to adopt attitudes and instruments, such as trade and investment, to accelerate the optimisation of water allocation and use, within global strategies. It has to be emphasised that many of the improvements in productive and allocative efficiency can only be achieved through investment.

Water is used and managed in political and cultural circumstances by people subject to profound and deeply held notions concerning its worth and value. Human institutions tend to change most effectively when new approaches are introduced with the grain of the culture. The importance of women in water utilisation and their actual and especially their potential role in improved water using practice has been emphasised in a number of conferences and reviews."

A strategy of developing the food production capacity of South Africa's neighbours is rational to allow them to become strong and self-sufficient.

The value of collaboration in disaster management

Sub-Saharan Africa experiences recurrent droughts and, in some areas, floods. As droughts create insecurities in water and food supplies and floods lead to loss of life and property, both require ameliorative measures.

Southern African rainfall is erratic, particularly in the drier regions. Accordingly, water lies at the heart of most Southern African disasters (excluding those which are manmade, such as environmental degradation and civil wars). There is either too little water during droughts or too much during floods. As the past few decades were notable for severe droughts, drought preparedness warrants particular attention. Nevertheless, while droughts affect the largest numbers of people, floods may hold the biggest threat to life. Drought preparedness is probably the most valuable form of regional co-operation.



Food supply Shortfalls Requiring Exceptional Assistance in 1993

Source: FAO 1994

Regarding the relationship of disaster mitigation to the environment, the simplistic approach of 'no more large dams' which is being promoted by environmental lobbies in some affluent, well-developed countries, is unsuited to the variable nature of Southern African weather and the need to manage water wisely in the interest of humankind, as well as the environment which must support life.

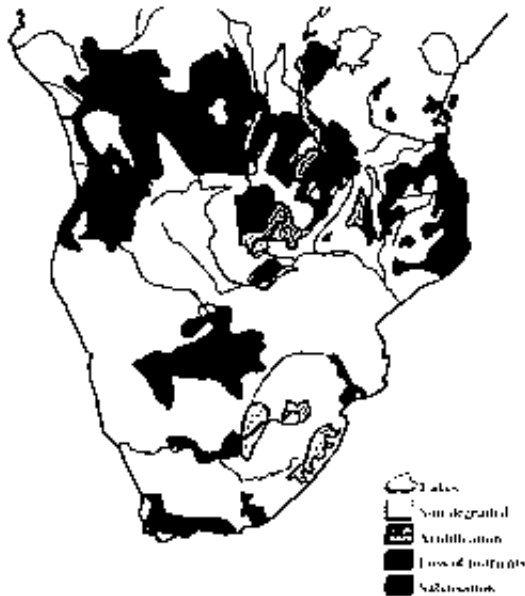
While demand management needs due attention, appropriate dam building must also be considered. It is only when countries achieve economic strength that they can support the sophisticated environmental management approaches which are made incumbent by population pressures. Before they have achieved economic security, people struggling for survival will wreck their environment out of sheer necessity. A choice is possible only after greater security and financial strength is attained through development.



Areas with Soil Degradation due to Overgrazing

(Click on the map for an enlargement)

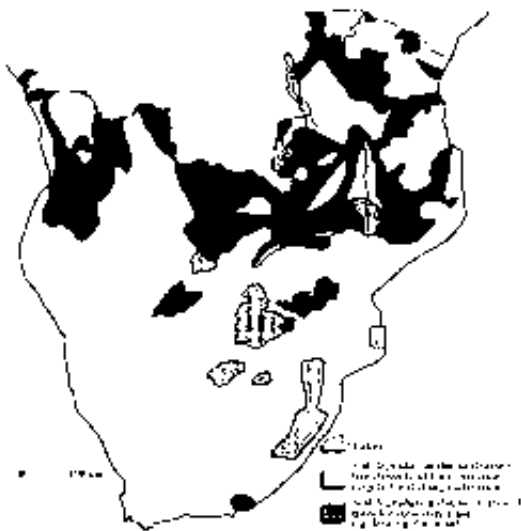
In Southern Africa, droughts seldom occur simultaneously in all countries (those to the north are mostly at less risk), making backup support possible. As agricultural success requires scientific management which encompasses risk evaluation, Southern Africa can profitably co-ordinate the use of the region's expertise in such a manner that the best returns are obtained. In this respect, the region's food security has been improved since the 1980s, with the Food and Agriculture Organization of the UN (FAO) playing a prominent role. The value of regional collaboration was evident during the recent (1991/92) drought, when the effective co-ordination of the transport of emergency food supplies contributed greatly to alleviating distress. The FAO's Global Information and Early Warning System monitors the world food situation and co-ordinates donations. Its prediction of the 1992 drought disaster contributed to speedy and effective relief. Accordingly a Regional Early Warning System having its headquarters in Harare, has now been established with support from the FAO and the World Bank.



Areas with Chemical Degradation

(Click on the map for an enlargement)

In addition, the recent initiative of the International Decade for Natural Disaster Reduction (IDNDR), has alerted countries to the need to examine their national provision for disaster management. This in itself tends to encourage better co-ordination, not only within countries, but also between countries. Once South Africa's national disaster management initiative is structured formally, (probably through an Act of parliament in 1996), South Africa will also be able to enter into formal, co-ordinated liaison with other Southern African countries.



Areas Affected by Deforestation

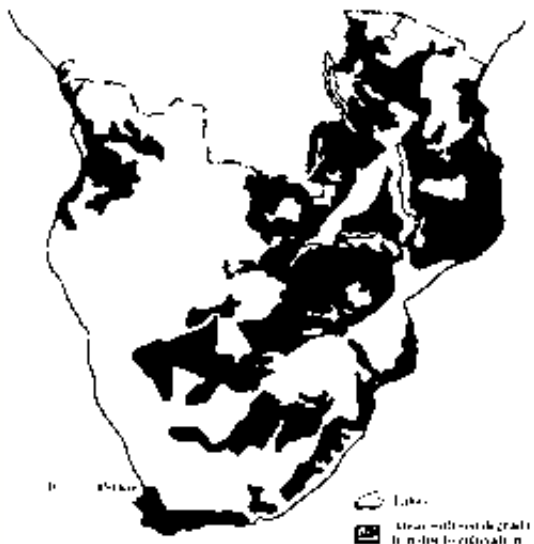
(Click on the map for an enlargement)

Regarding floods, collaboration is needed to determine appropriate standards for land use to assist proactive flood management. Collaboration can also help the region to cope with inundation resulting from large weather systems, such as tropical cyclones. Activities can extend from predictions (such as the dissemination of information from the Tropical Cyclone Centre for the Indian Ocean at Reunion), to assistance in rescues, reconstruction and rehabilitation.

Collaboration in weather services

As early warning systems depend on weather predictions, the value of Southern Africa's weather services can be enhanced by regional integration.

Each country runs its own national weather service, which measures weather elements to maintain a climate database. The measurements are shared with other countries so that they can operate national forecasting services. These services usually comprise a national service for the country, an aviation service and, if necessary, a maritime service. To a growing extent, five-day forecasts of weather patterns are now being obtained from overseas computers. Each national service interprets them according to its particular climate and topography.



Areas with Soil Degradation due to Cultivation

(Click on the map for an enlargement)

The scenario for long range weather outlooks, severe weather warnings and, in particular, droughts, is changing. A combination of the increasing satellite information, the longer forecasts by computer models and more rapid communication, are extending the ability to provide seasonal rainfall forecasts. These predictions usually emanate from a few large weather centres and are distributed to national weather services. Southern Africa is served by two Drought Monitoring Centres, in Nairobi in Kenya and in Harare in Zimbabwe. Here the rainfall data for the whole of South and East Africa are compared with cloud details from satellites, and rainfall reports are issued for the entire region. Assessments regarding agriculture, drought and prospects of rain for the following six months are included.

Although weather monitoring and forecasting have always relied on international co-operation, the efficient utilisation of improved weather assessment products needs better linkages between the weather services which generate these products and the national services that disseminate the information in a manner suited to their own countries. These responsibilities are co-ordinated world-wide by the World Meteorological Organization (WMO), acting within the UN. As a result of its strong technical base, the WMO has recently designated South Africa as the Regional Telecommunication Hub for Southern Africa, for the purpose of regularly updating regional weather predictions on the Global Telecommunications System. South Africa has recently been appointed by the WMO to deal with longer term (monthly and seasonal) weather forecasts. Being committed to continuous basic research, South Africa intends to remain at the forefront of science. Botswana has also acquired an instrument calibration centre through the WMO, which augurs well for an emerging pattern of distributed meteorological responsibilities. Drought Monitoring Centres to the north are being co-ordinated through computer links to benefit the region. The enhanced information which is now available to Southern Africa through all these activities will hopefully improve food security and reduce the impact of disasters.

A SADC report of 1990 revealed that the hydrological services in the region had deteriorated seriously. It concluded that the hydrological services were inadequately equipped and offered inferior water resources information to effectively and significantly contribute to water resources development and management. Therefore, various water resources programmes aimed at improving water management, are being implemented at regional and national levels.

CONCLUSION

A paradox in Southern Africa is that the overall prosperity in the South, where the water and land resources are sparse, is less evident towards the north where these resources abound (although the rainfall is irregular). Based on the evidence of what can be achieved through scientific management with less resources, the untapped potential for a better quality of life for the more northern nations must surely be immense.

However, even amidst plenty, it makes economic sense to use resources wisely, particularly when the environment must be safeguarded to be able to maintain its ability to nurture life. This implies that, ideally, each of the various types of water uses should be so located in the region as to achieve the best overall advantage through collaboration. Thus, if voluntary actions which make economic, social and environmental sense were to become the driving force behind the region's collective endeavour, it could raise Southern Africa to the stature of other emerging economic blocs in the world by spearheading the evolution of a regionally diversified economy.

By choosing how best to engage in voluntary trade, each sovereign state can forge its own destiny. The wise employment of the disparity in the subcontinental distribution of basic natural resources and advanced skills could thus become a powerful instrument of stability and peace.

As stated succinctly by the Financial Mail "*the whole sum of the resources of the region is worth more than the parts.*" All that is required, is the vision and the will to advance. As Edward de Bono has said, "*[w]e can no longer wait for drift and crisis management to carry us forward to a better future; instead we have to make a deliberate effort to secure a positive future. The call is to arms: not the outmoded arms of gun and bomb but the focused power of human thinking unleashed from its pettiness.*"

ACKNOWLEDGEMENTS

Data sources on water in Southern Africa reveal major disagreements. These are probably attributable to the paucity of adequate measurements and the lack of that level of scientific co-ordination which is vital to reduce risks in entrepreneurial ventures. The main sources of data used in this paper are recent reports (as listed in the references). While they do not agree in many instances, the figures selected for quotation are considered adequate for a broad, indicative overview such as this. The author is also indebted to personal communications from Prof J A Allen of SOAS, M V Laing, Director of Climatology of the South African Weather Bureau, as well as Messrs S van Biljon, Director of Hydrology, E Bruane, Director of Geohydrology, C Swiegers, Deputy Chief Engineer, W Rowston, Deputy Chief Engineer, of the South African Department of Water Affairs and Forestry.

The views expressed in this paper are those of the author and not necessarily those of the South African Department of Water Affairs and Forestry.

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