SEA OF SAND, LAND OF WATER:
A SYNOPSIS OF SOME STRATEGIC DEVELOPMENTAL ISSUES CONFRONTING THE OKAVANGO DELTA

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Water Issues Study Group,
School of Oriental and African Studies (SOAS)
University of London

A.R. Turton
art@icon.co.za & at31@soas.ac.uk

INTRODUCTION:

Before one can begin to grasp the complexities that confront a developing country in an arid region, one needs to understand that a set of fundamental issues drives this whole process. The purpose of this paper is to try and isolate what the author believes to be some of these fundamental driving forces. The case study that will be used has been carefully selected, as it illustrates these fundamental dynamics in a manner that could be described as being in a near text-book fashion. Botswana is an arid country. It is also a country that has been independent for a relatively short space of time. At independence in 1966 it was one of the poorest countries in the world. Today, some thirty years later, it has a strong and growing economy, a stable multiparty democracy, and it has become one of the only countries in Africa to contribute to the International Monetary Fund. In short, Botswana is an African success story. Yet there is every reason why this should not be the case. The climate is harsh and arid, and the population growth has reached a point where it is beginning to outstrip available water supply. Botswana could have been a failure instead. The question is therefore raised, can Botswana sustain this rate of development or will environmental collapse be its ultimate fate? This paper will explore what the author considers to be six critical strategic issues confronting the Okavango Delta, a 15 000 km^2 wetland system, which is the only significant surface water resource available in the otherwise arid country. It will also present the relevant theoretical aspects needed to make an informed analysis of the problems.

BACKGROUND:

In order to grasp the developmental complexities confronting an arid state like Botswana, one needs to understand five key hydropolitical facts. These are as follows:

- Key Hydropolitical Fact # 1: Probably the most important developmental problem in the arid portions of Southern Africa is the fact that **water is unevenly distributed in spatial terms**. In other words, where water is found in any great abundance, it tends to be located far from existing population or development centres. This means that in order to be effectively harnessed into economic potential, water has to be moved over great distances and at great costs. Botswana illustrates this graphically.

- Key Hydropolitical Fact # 2: As a direct result of the spatial maldistribution of water, existing sources of water become critically important in **strategic terms**. This generally means that they become exploited to a point where the resource base may eventually collapse. In Botswana, the Okavango Delta is the only source of permanently running surface water within the state borders. The Okavango Delta case study thus offers a textbook example of the problem being analyzed.

- Key Hydropolitical Fact # 3: The problems related to the critical strategic importance of existing water for states in arid regions is compounded by the fact that **existing supplies originate in other countries**. This is called exogenous water in hydropolitical terminology. This introduces a critical variable into the overall hydropolitical equation – that of riparian position (and overall dependence on the actions of upstream riparians over which the downstream partner has little or no control). In the case of Botswana, 94% of all available surface water originates from outside the borders (Gleick, 1993:108). The importance of this fact is reinforced when one notes that the ratio of external water supply to internal water supply for Botswana is 16.9:1 (Gleick, 1993:108) which is very high.

- Key Hydropolitical Fact # 4: The Okavango Delta is what can be described as a terminal lake or water body. A **terminal water body** can be defined as being a body of water without a surface outflow. The problems related to the development of water resources from a terminal system relate to the fact that the level of the water body in question is a function of the balance between surface inflow and net evaporation minus precipitation (Micklin, 1994). In this regard, lessons that have been learned from the Aral Sea can be used to gain a greater understanding of what the implications of this unique situation are in developmental terms.

- Key Hydropolitical Fact # 5: **Aridity** means that the naturally occurring precipitation is lower than the potential evapotranspiration demand (Arnestrand & Hanson, 1993:20). This is a completely natural phenomenon, which means that more water is lost through either evaporation or transpiration via plant stomata than falls naturally. In the case of the Okavango Delta, evapotranspiration accounts for some 96% of the total water loss from the overall system (Scudder *et al.,* 1993:361). The significance of this fact in developmental terms is essentially threefold.

  1) Water **resource managers** are tempted to regard this as an unnecessary loss of vitally needed water and therefore try and do something to attenuate it.

  2) Although the overall water resource may at first glance appear to be substantial, in reality the **exploitable component** of the total water available is in fact considerably small.

3) **Irrigation** is not a viable option as most of the water will simply be lost to evapotranspiration.

ECOLOGICAL DYNAMICS OF THE DELTA:

Having been introduced to the five key hydropolitical facts that form the background to any understanding of the development-related constraints that confront states in arid regions, it now becomes necessary to gain an understanding of the forces that drive the ecological dynamics of the Okavango Delta. The point of departure for this portion of the paper is based on the rationale that **sustainability is the best normative basis for any development-related policy** for states in arid regions to adopt because it means living within the constraints that the environment has placed on developmental potential. This notion of sustainability will be expanded on later in the paper. For the moment, it is sufficient to accept that sustainability is a desirable state of affairs, simply because a non-sustainable option will ultimately cause environmental collapse, bringing with it major social implications. There are essentially six major natural forces at work within the Okavango Delta. By understanding how these forces work in dynamic interaction with one another, it is hoped that the non-technical reader will be able to ultimately recognize why it is important to maintain the overall ecological integrity and viability of the Okavango system as a whole. These are as follows:

- Natural Force # 1: By far the most important driving force to the overall dynamics of the Okavango Delta is related to **water quantity** or volume. In this regard there are essentially three main quantity-related aspects that need to be understood.

    1) By far the major factor is that which results from the **seasonal flooding** and ebbing of water. This can be likened to a rhythmic pulsing of life throughout the system. The water that flows into the Okavango Delta drains from the highlands of Angola. Angola is relatively water-rich, and the seasonal distribution of precipitation is generally reliable. This means that the flooding and ebbing of water in the Delta reach of the Okavango Basin is reasonably predictable.

    2) The second major quantity-related factor is the **temporal dimension** of the flooding. The timing of the floods triggers off a whole host of ecological responses, such as the breeding cycles of a variety of biota. It is also known that wetlands are nutrient sinks (Ramberg, 1997a), providing life-sustaining nutrients in an otherwise hostile environment. Thus the ebb is important as it results in lush grasslands deep within the heart of an otherwise desert-like environment. These lush grasslands are used by herbivores and also by man for the cultivation of crops.

    3) The significance of this dynamic of flooding and ebbing is the fact that there are in essence **three major habitat types** within the Delta that are uniquely distinct from one another (Ramberg, 1997a). These relate to the permanence or absence of the resultant wetlands. Flooding causes the water to burst from its normal course and inundate the surrounding land. These seasonal wetlands expand and

contract in direct relation to the magnitude of the flooding. These seasonal floodplains are also very prolific sources of food and energy for a larger ecosystem on which both man and animal have become dependent. The base-flow component of the natural cycle is linked to the existence of **permanent wetlands** (Ramberg, 1997a). The magnitude of these permanent wetlands is directly proportional to the magnitude of the base-flow. On the other hand, the flood component of the natural cycle is linked to the existence of **seasonal wetlands** (Ramberg, 1997a). The magnitude of these seasonal wetlands is directly proportional to the magnitude of the flooding. The portions adjacent to the swamps that never receive water are almost permanently dry, and **sandveld tongues** also penetrate the swamps, providing the third distinct type of habitat.

- <u>Natural Force # 2</u>: The next most significant natural force at work in the Okavango Delta can be understood as the opposite of Natural Force # 1. This second natural force is that of **evapotranspiration**. The magnitude of the evapotranspiration is what acts as a counter-balance to the inflow of water caused by annual flooding. There are two components to evapotranspiration. These are:

  1) **Evaporation** refers to the amount of water that is lost directly from an open stretch of water to the atmosphere. Evaporation from Maun for example, is in the order of 2,169mm per annum (Scudder *et al.,* 1993:290). This can be misleading however, and may not be directly transferable to the Delta itself. This is because evaporation is related to wind speed and prevailing humidity. On the edge of the swamps, wind speed can be higher than deeper in the Delta. Humidity also fluctuates in both spatial and temporal terms. Spatially, humidity is higher in the centre of the forested portion of the Delta than the more open grassland fringes. Temporally, the humidity fluctuates with the seasonal changes. It has been determined that evaporation rates vary with rainfall (Scudder *et al.,* 1993:292).

  2) **Transpiration** refers to the amount of water that is lost directly as the result of plants transpiring. The Okavango Delta is heavily populated with a wide variety of plant species. It has been noted by Scudder *et al.,* (1993:290) that transpiration accounts for the major portion of the evaporative losses from the Okavango system. The significance of the dominance of transpiration over evaporation is that the occurrence of saline surface water in the Delta is rare (Ellery & McCarthy, 1994:165). This means that the water is of such a quality that both man and animals can use it. This is illustrated better when one considers the Makgadikgadi Salt Pans, which are also an extension of the overall Okavango system, but where salinity exists because of the high prevailing evaporation rate.

- <u>Natural Force # 3</u>: A significant but relatively benign natural driving force at work in the Okavango system is related to **water quality**. There are three distinct components to this ecological aspect. These are:

1) The water is generally extremely clear with **low turbidity**. Turbidity can be understood as fine matter that is suspended in the water. This means that various animals such as the otter can rely on visual acuity to hunt (Ramberg, 1997a).

2) The water has a **low nutrient load**. This condition is known technically as being oligotrophic. In fact, the Okavango waters have been described as being hyperoligotrophic due to their extremely low levels of nitrogen and phosphorous (Ellery & McCarthy, 1994:163). This enables the water clarity to be maintained. It also means that the Water Hyacinth problem that prevails in many aquatic systems in Africa is not yet found in the Okavango system. Due to the prevailing low nutrient levels in the water of the Delta, there is a natural inhibition to plant growth. This has meant that ecologically, the Delta has evolved in a rather unique way. The chemical elements that the swamp needs most to survive on, nitrogen, potassium and phosphorus are largely contained within the plants themselves, specifically within their root zones (Thompson, 1976:73). In fact nitrogen is introduced into the system by natural nitrogen fixing bacteria that are found in the root zones of lake-edge papyrus swamps, whose floating islands create a favorable substrate to support these valuable microorganisms.

3) The water flowing into the panhandle of the Okavango Delta has a very low **sediment load** (Ramberg, 1998). This is not to be confused with turbidity and can best be understood as solids that are "rolled along" by the water but which are not suspended in the water. This means that siltation is generally not a problem within the Delta as it is elsewhere in Africa. However, silica sedimentation is an important natural process. The accumulation of bed-load sediment in primary channels causes aggradation by up to 5cm per year, leading to the elevation of the channel above the surrounding terrain, resulting ultimately in channel failure (Ellery & McCarthy, 1994:165) which is a natural process.

- <u>Natural Force # 4</u>: The Delta exists on a **seismically active** area. The Okavango River flows from the Angolan highlands across the Caprivi Strip in Namibia into the Kalahari Depression. The reach of the system that forms the Okavango Delta is characterized by flat, featureless terrain. For example, the path followed by the Okavango-Nqoga-Boro-Thamalakane channel descends only 62m over a 442km length of river, representing a gradient of over 1:7,000 (Scudder *et al.,* 1993:279). The significance of this flat profile is that the water forms a delta as soon as it finally drops from the Popa Rapids in Namibia. Sediments that have been deposited over time have created a large alluvial fan upon which the Okavango Delta wetland has developed (Ellery & McCarthy, 1994:161). The flat portion of the Kalahari Depression is perched above a seismically active area however, being traversed by a number of known fault lines. Various researchers have linked this faulting to a tectonic connection with the Great East African Rift Valley (Hutchins *et al.,* 1976:13). These faults shift from time to time. With each shift comes a minor change in the overall orientation of the Delta. For example, there was a major earthquake in 1952, which was known to have caused a change in the drainage pattern of the Delta (Hutchins *et al.,* 1976:17). This particular earthquake measured 6.7 on the Richter

Scale (Scudder *et al.,* 1993:374; Ellery & McCarthy, 1994:161). The two important fault lines are the Thamalakane Fault and Kunyere Fault that effectively forms the "wall" against which the water banks up at the distil end of the system, forming the delta. The expected occurrence of seismic events in the order of magnitude of 6 – 6.5 on the Richter Scale is one event every 25 – 50 years (Scudder *et al.,* 1993:374). The significance of this seismicity is the fact that it introduces a fundamental variable into the over ecological equation. Seismicity could affect river flows and water distribution through existing distributaries (Scudder *et al.,* 1993:279), and could also affect recharge to shallow groundwater aquifers such as the Shashe aquifer (Scudder *et al.,* 1993:374). This is one of the driving forces behind the shifting nature of the permanent wetlands as well as human distribution. What has been wet in the living memory of an individual human being, may well have been dry in the past, and may well be dry again some time in the future. Where groundwater wells on which humans depend existed before, there is no guarantee that such wells will exist forever.

- Natural Force # 5: Another natural phenomenon that affects water distribution throughout the Okavango Delta is **channel blockage** caused by aquatic vegetation in conjunction with siltation. Peat forming swamps have developed alongside the river, which have confined the normal flow over the otherwise flat terrain. These banks of living or dead organic material, trap whatever silt exists (Scudder *et al.,* 1993:279), and form natural levees of considerable durability. Channel beds thus become elevated above their surrounding floodplains until such time as a levee ruptures or the channel becomes blocked by vegetation. This diverts water elsewhere. Ellery & McCarthy (1994:163) describe this natural process as starting "with constriction of the channel by *Vossia Cuspidata* at its distal end, followed by the development of *Cyperus Papyrus* blockages and by encroachment of papyrus from the banks into the channels, leading ultimately to their complete obliteration. With the reduction in water supply, peat deposits flanking the channel burn in subsurface peat fires. This leads to the complete destruction of swamp habitat, and the area reverts to dry land". This factor introduces yet another variable into the overall ecological equation that defines the functioning of the Okavango Delta. The peat fires release trapped nutrients, providing fertility to the lush grasslands that emerge afterwards.

- Natural Force # 6: The whole Okavango Delta is best understood as being an extremely fertile oasis that has thrust its way into the Kalahari. To this end, Ellery & McCarthy (1994:161) note that, "the low rainfall and infertile sandy soils are the most important **environmental variables** that affect the vegetation of the region around the Delta". In other words, this can be understood in terms of being a dynamic interaction between encroaching desert sands being forced back constantly by the reliable availability of water on a local scale. If the surface water from the Okavango River system were lost, then the desert would ultimately encroach.

The Okavango Delta can thus be understood as being the interface between sand and water if one considers these natural forces that are constantly at work. When more water is available, then the Delta expands, pushing back the desert. Conversely, when less water is available the Delta shrinks and the desert encroaches. The author understands the Okavango wetland system as being best described as a sea of sand and a land of water.

THEORETICAL CONSIDERATIONS:

Having noted the six major natural forces that drive the ecological dynamics of the Okavango Delta, it now becomes appropriate to focus on some of the theoretical considerations that need to be understood within the context of a discourse on sustainable development. In broad terms, there are four major theoretical considerations. These are:

Theoretical Consideration # 1: Understanding the concept of a '**threshold**'.

A useful scientific contribution comes from Micklin (1994), who did a study of the Aral Sea. As previously noted, the Aral Sea is similar to the Okavango Delta in that both can be regarded as terminal systems. Micklin's study shows that major economic and ecological consequences emanate due to the long-term abstraction of water from a river basin in an arid region. In this case, the Aral Sea has shrunk from a surface area of 66 900 km^2 in 1960, to a projected area of 23 149 km^2 by the year 2000. The primary reason for this is that after 1960, irrigation expansion required ever more water per hectare as long unlined canals were extended into the desert, reducing the overall efficiency of the system (Micklin, 1994:115). The results of this have been labeled the second largest ecological disaster in the former Soviet Union after Chernobyl (Micklin, 1994:114). Rodal (1996) notes that "authoritative studies support the view that in significant measure the Soviet Union collapsed because of the way in which it treated the environment". The policy-makers in Botswana should therefore ensure that the same fate does not befall their citizenry due to poor decision-making at the strategic level.

The environment is therefore important if sustainability is to be achieved. One of the important lessons to be learned from the collapse of the former Soviet Union, is that "special attention needs to be paid to **identification of 'thresholds'** – sensitivity points in the operation of a system which, if transgressed by an external disturbing force, cause the system to undergo unexpectedly rapid change" (emphasis added)(Micklin, 1994:121). In other words, aquatic systems tend to be ecologically sensitive in arid regions, and they can suffer abuse up to a point beyond which failure becomes both rapid and catastrophic. Long-term ecological, social and economic problems result. The Aral Sea thus offers a classic case of unsustainable development policies at work. After all, sustainability really means living within the constraints imposed by the environment, ensuring that as much harmony as possible exists between man and his life-support system - the water landscape in which he lives. In other words, if seen this way, it is no longer an issue of man versus the environment, and it becomes rather an issue of understanding man as an integral part of the environment in which he lives.

Because a large portion of the water used for developmental purposes in arid regions is surface water, the question arises as to what the threshold of sustainability is when planning sustainable abstraction of the resource. O'Keeffe *et al.,* (1992: 290) introduce a useful concept known as the '**inflection point**'. This can be used as an indicator of a threshold of sustainability, provided it can be accurately assessed and quantified. In terms of this concept, it is necessary to understand that an aquatic system consists of a number of distinct habitats. Some are more vulnerable than others. For example, riverbanks can survive for a period of time with a low flow regime. The benthic (or bottom) habitat is more sensitive however, and cannot survive for long if allowed to dry out. This is because this habitat contains the eggs, larvae and adult forms of various biota which will simply die if the life sustaining water is removed. This is better illustrated by means of a diagram. Figure 1 shows a cross section through a hypothetical stream showing two levels associated with different flow regimes.

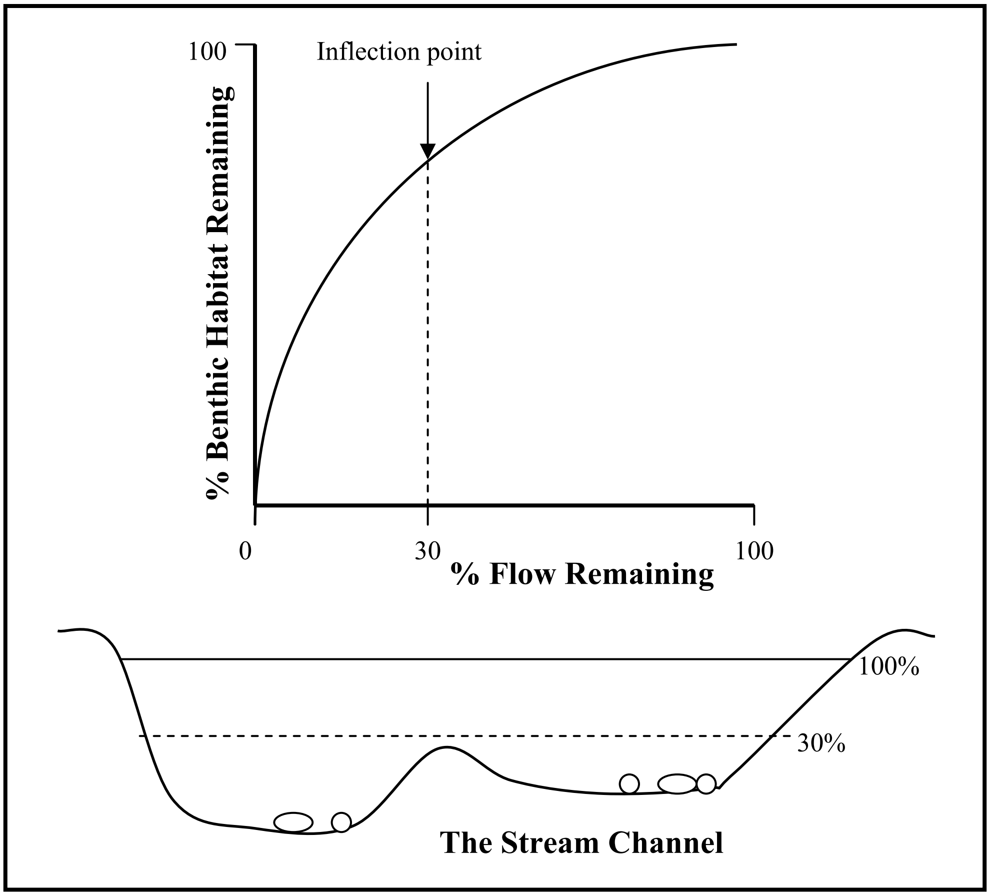

Figure 1. Cross-section of a hypothetical stream showing effects of flow reduction and the corresponding 'inflection point' (after O'Keeffe *et al.,* 1992:290).

The highest level corresponds with a 100% flow situation. In this condition, the riverbanks are inundated and the biological functioning is ensured. At a low flow condition, representing an arbitrary 30% of full flow, it can be seen that although a large volume of water has been removed, relatively small portions of the respective riverbanks are exposed. The sensitive benthic habitat is still protected under these reduced flow conditions, meaning that the biological activities within that habitat are still functioning in a sustainable manner. Additional abstraction of water below this level will expose progressively larger areas of the benthic habitat, thereby reducing the sustainability of the ecosystem. This can be regarded as the 'inflection point' as illustrated on the corresponding graph. An important aspect to note in terms of this thinking is that for sustainability to be maintained as a policy position, abstraction must be controlled. A critical component of this is the normative acceptance that the ecosystem concerned is a legitimate consumer of its own water and should be granted protection of this fact as a right. This should then be built into the operating rules for impoundments. This enables development to occur in a sustainable way, as the environmental integrity of the overall water landscape is not compromised in the process.

The significance of the concept of the 'inflection point' becomes apparent when considering a cross-section of the Okavango River. Smith (1976:93) offers an illustration of a typical profile of the Cubango River in the "Miombo Zone" which is presented as Figure 2.

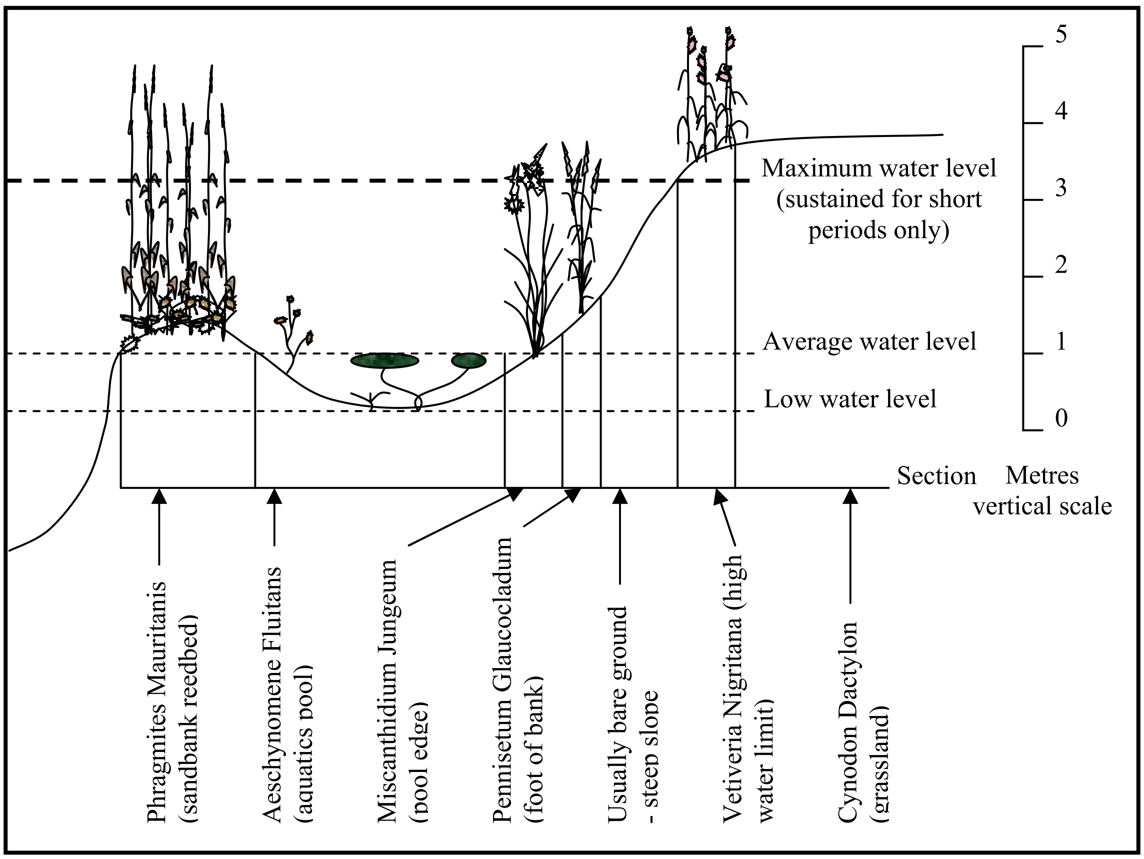

Figure 2. Idealized profile of typical bank vegetation of the Cubango River in the "Miombo Zone" of the Okavango Basin excluding woody species (after Smith, 1976:93).

The Cubango River is in the upper reaches of the Okavango Basin in Angola. The Cubango River becomes the Okavango River further downstream. The two rivers are essentially the same with different names in different countries. From Figure 2 it is evident that by reducing the flow below the low water level for prolonged periods of time, due to excessive abstraction of water, the riparian habitat would be destroyed. This would mean that subsequent flooding would damage the unprotected banks, resulting in bank scouring, erosion and excessive downstream siltation. It should also be noted that the profile of the river corresponds markedly with that presented in Figure 1.

Sustainability is thus an important policy-related issue for states in arid regions. In order for sustainability to occur however, attention needs to be paid to the concept of the 'inflection point' as this provides the policy-maker with a parameter against which the overall management of the ecosystem can be measured. If this is incorporated into a set of operating rules, say for dam management in the upper Okavango Basin, then environmental degradation can be reduced and sustainability can be ensured. This means that the Instream Flow Requirements (IFR) need to be quantified and this data subsequently used as a management parameter if sustainability is to be realistically attained. Current experiences in South Africa show that this is initially a technically complex but ultimately necessary process.

<u>Theoretical Consideration # 2</u>: Understanding the '**water landscape**' and the dynamic relationships between '**population**', the '**environment**' and '**development**' within that landscape.

In arid regions the environment is usually more fragile and thus easily prone to catastrophic degradation. This needs to be understood by policy-makers and analysts alike. Falkenmark (1994) best illustrates this point by way of a model, which links three critical variables; the environment, population growth and development. This is presented as Figure 3.

Falkenmark (1994:10) notes that there has been an, "almost complete conspiracy of silence in the international arena regarding a closely related form of environmental scarcity: the population-driven scarcity of freshwater". In terms of this, it is necessary to address the linkages between drought and desertification. It is also necessary to begin to estimate the major threat in the area of water shortage that is emerging from the unavoidable population growth related to mothers that are already born. To this end, land degradation and desertification have been major driving forces behind the displacement of people. One classic example from the last century was the famine and hardship-driven Irish migration to North America. In this century, Africa has witnessed a number of drought-driven migrations to neighboring countries (Falkenmark, 1994:11). Inter-state migration tends to be triggered by droughts. An example is the almost continuous movement of people in the 'hunger crescent' through the semi-arid sub-Saharan Africa. This is significant for Botswana, as it is a relatively wealthy country that can easily be targeted by economic or environmental refugees in future.

For this reason, it is increasingly important for inter-disciplinary research to be done in order to understand the complexities of the problem. In an attempt to stimulate this inter-disciplinary research, it is necessary to understand the **concept of the 'landscape' as a life-support provider**. To this end, development takes place by means of the interaction of two worlds:

- The landscape reality.
- The human perceptions of that reality.

Falkenmark (1994:12) notes in this regard:

> "The word used for the landscape reality has been "environment". In the past, the diagnosis of the population-environment-development dilemma has suffered from fundamental perception problems. The literature tends to draw attention to linkages and to linkages between linkages, rather than to make a systems analysis. Even studies of global food supply tend to be crude and simplistic. The relations between environment, development and population have been discussed as triangular linkages, with the complications that follow from the fact that the linkages are also mutually linked.
>
> Even if the environment-development-population linkages could in the past be discussed in terms of correlations and regressions with quantifications based on earlier observations, this will not be true for the linkages of the near future. The reason is simple: since things change with time in all three realms, rather than thinking of a static triangular linkage relationship, it is preferable to think in terms of a spiral along the time axis."

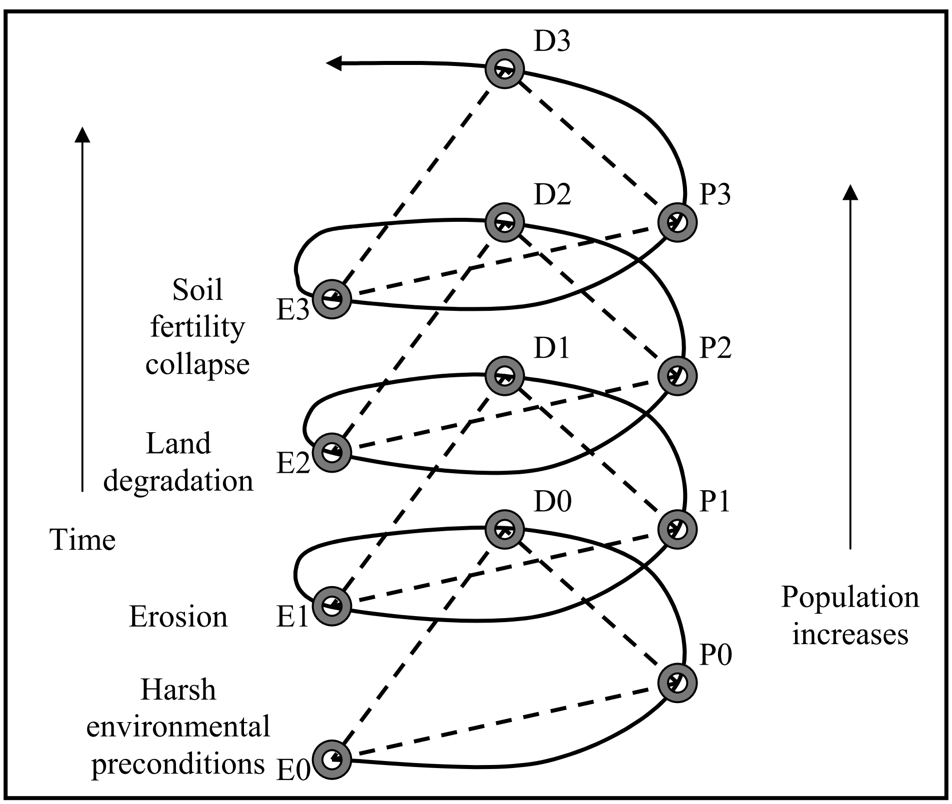

Figure 3. Time-driven spiral symbolizing the changing relations between Population (P), the Environment (E) and Development (D) (after Falkenmark, 1994:12).

Falkenmark's model shows that as the 'population' (P) grows, there is a corresponding need for a larger population-supporting capacity, otherwise known as 'development' (D). In order to meet these new demands, the 'environment' (E) starts to deteriorate. This in turn reduces the population-supporting capacity of that environment. This model thus shows the increasing risk of conflict and competition as time passes, whilst bringing the reduced environmental capacity to respond to the increasing demands into the equation. This is particularly useful for understanding the socio-political dimension presented in arid-region developing countries that face a rapid population growth. Arid-region environments are particularly susceptible as their ability to "bounce back" is greatly reduced as a result of the prevailing limitation caused by low precipitation levels, making this model all the more valuable as a conceptual tool. This again reinforces the need to be able to identify 'thresholds', as the gradual transition from one condition to another set of conditions could lead to sudden dramatic and catastrophic changes in the life-support provider – the water landscape.

Prevailing **hydroclimatic conditions** pose finite constraints on the population-supporting capacity of rainfed agriculture, as well as the vulnerability of soils in terms of the propensity towards crust formation and erodibility (Falkenmark, 1994:13). This is highly relevant in the Kalahari, specifically in the grasslands around the Okavango Swamps. The aridity of a region and consequently the biomass productive capability of that region, is a function of the following finite factors:

- The amount of **precipitation** that falls as part of the hydrological cycle.

- The loss to the atmosphere as a result of **evapotranspiration** (evaporative demand).

The life supporting capacity of the 'landscape' may be disturbed in three main ways (Falkenmark, 1994:13-4).

- **Pollution** resulting from improper waste handling. (Upstream of the Delta).

- **Land degradation** as the result of over exploitation of vulnerable soils. (Excessive cattle grazing and general over-utilization of the infertile soils around the Delta).

- Livelihood problems which emerge when the demand increases beyond the productive capacity, forming a **resource-scarcity** situation. The concept of a 'threshold' is thus highly relevant, and terms such as the 'threshold of sustainability' are extremely important for policy makers seeking to effectively manage long-term developmental projects. Quantification of this 'threshold' is not so easy to achieve however. One aspect of this is IFR determination, which is currently a major priority in the South African water sector so the expertise is available within the region.

Sound development requires an integrated strategy on a catchment basis (Falkenmark & Lindh, 1993:89). How then can this be achieved, in a region where states are relatively newly independent and are consequently somewhat jealous of their sovereign integrity? (Turton, 1999a).

Theoretical Consideration # 3: Understanding the concept of '**blue water**' and '**green water**' and their dynamic interaction within the '**landscape**', specifically regarding the policy relevance thereof.

In terms of the productive functions of water, Falkenmark (1994:13) introduces two useful new concepts:

- '**Green water**' production is based on the amount of water passing through the actual root zone and consequently generating biomass. If the 'green water' stops flowing, so does biomass production. There is thus a direct relationship between the availability of 'green water' and the agricultural productive capacity of an ecosystem. The significance here is that the water is lost to the system by transpiration once it has been used. This also explains how a drought can actually exist when water is apparently in relative abundance. This can be understood in terms of a 'green drought' or absence of water from the root zone of plants at a critical time. 'Green water' is therefore relatively inefficient at converting scarce water into a contribution to the Gross Domestic Product (GDP) of a state in an arid region.

- '**Blue water**' production is derived from surface water found in rivers and groundwater found in aquifers, and involves socio-economic activities. This 'blue water' is available for use, and re-use, as it passes through the water landscape. The significance here is that the water is not necessarily lost to the system and it can be recycled, possibly being used as 'green water' towards the end of its recycled life. 'Blue water' is therefore relatively more efficient than 'green water' at converting scarce water into a contribution to the overall GDP of an arid state.

Thus the concept of '**environmental scarcity**' needs to be better understood (Falkenmark, 1994:13). Crudely put, the term 'environment' means the system that surrounds human beings. The problem with this simplistic understanding is that when the scale of human population and use increases, the concept of 'environment' becomes vague to the point of becoming meaningless. It is more useful then to think of the concept in terms of the biophysical system that provides the human population with its life support. The 'landscape' is then seen as the life support provider through its functions of hosting the natural resources and processes on which sustainable development depend.

Taking this one step further, it can be said that where there is no more water, people simply cannot survive and they have to leave. This was dramatically illustrated in recent times by the risk of evacuation of Bulawayo (Zimbabwe) during the 1992 drought (Falkenmark, 1994:14). Water availability was so scarce at that time, that the sewers even stopped functioning, necessitating a co-ordinated peak flow situation daily. This was done by means of communicating over public radio that at a given time each day, toilets had to be flushed. This enabled a peak flow to be artificially generated, which flushed out the sewers daily, thereby preventing a total collapse of the system with potential health risks.

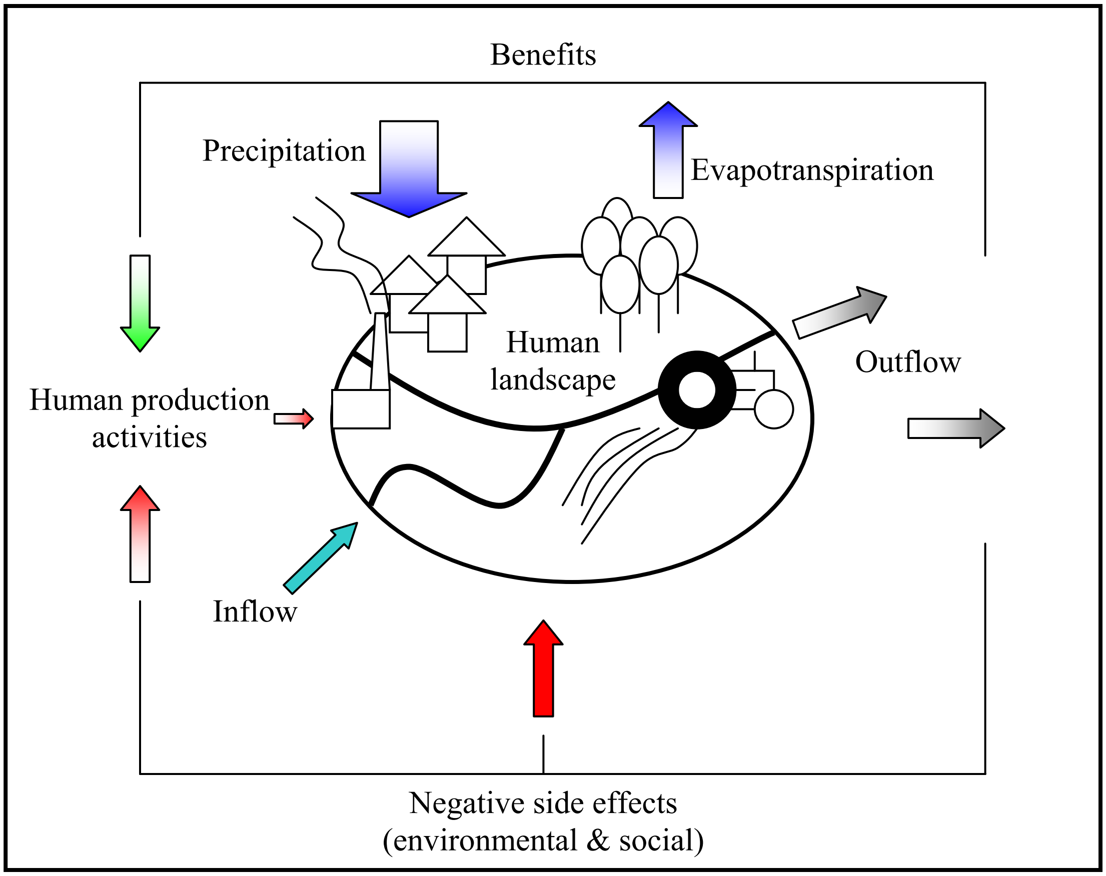

Figure 4. The water landscape showing that water availability in the landscape determines both the productive capacity and negative side effects of water use (after Falkenmark & Lindh, 1993:88).

Another aspect related to water as an economic developmental inhibitor is that which is broadly referred to as 'desertification'. This concept, which is linked to soil fertility and the resultant productive capacity of that resource, is somewhat confusing and therefore in need of conceptual clarification. This is relevant to a deeper understanding of the overall significance of the Okavango Delta as a vital ecosystem within Botswana.

Falkenmark (1994:15) notes that '**desertification**' basically refers to the loss of soil fertility resulting from a whole set of causal factors. These are loss of fertility manifested as a:

- **water deficiency** in the soil. More precisely this is 'soil desiccation'.
- **nutrient deficiency** in the soil.
- surplus of water and/or salt in the soil, also known as waterlogging and/or **salinization**.
- erosion of fertile soil on devegetated slopes, also known as **highland degradation**.

From this, it can be seen that only one aspect of deficient soil productivity is the shortage of soil water. This shortage simply impedes crop growth because there is insufficient water available in the root zone ('green water') to meet the biomass creating demand. This **soil-water deficiency** is caused in two ways (Falkenmark, 1994:15):

- Lack of **precipitation**. (In other words a shortage of rainfall as is the case with the Kalahari in general).
- Lack of **soil permeability**. In this context, precipitation that may fall is not able to percolate into the soil and root-zone of the plants. Instead it is transformed into flash floods with resultant erosion and siltation. (This is more relevant to the upper reaches of the Okavango Basin but also applies to the Delta).

Both of these causal factors, when combined with drought, result in local deficiencies in soil productivity resulting directly from the shortage of 'green water' needed by plant life to photosynthesize. Thus 'soil desiccation' is only one manifestation of 'water scarcity'. Droughts, on the other hand, are more intense in regions that experience lower precipitation levels, and different **modes of 'water scarcity'** tend to appear in parallel (Falkenmark, 1994:16). The hunger crescent in Africa is thus characterized by:

- A **scarcity of 'green water'** manifest in a short growing season due to the limited precipitation both in terms of volume and seasonality.
- **Recurrent drought** as part of the normal climatic patterns due in part to the disturbances in spatial distribution of water vapour in the global hydrological cycle.
- **Dryland desiccation** exacerbating the scarcity of 'green water'.
- **Scarcity of 'blue water'** being the surplus rainfall available to recharge aquifers and rivers that could subsequently be used in socio-economic production.

Thus we have the situation where in arid regions, prevailing environmental preconditions become problematic for human activities, where large parts are characterized by precipitation which is either too erratic, or too limited, to allow for the full development of crops during the short wet season. This results in the extreme vulnerability to crop failure as a normal condition. Conceptually speaking, this **multiple environmental vulnerability** can be expressed as (Falkenmark, 1994:16):

- Lack of '**green water**'.
- Lack of '**blue water**'.
- Recurrent and cyclical **droughts**.
- High **evaporative demand** that causes precipitation to immediately be lost to the atmosphere.
- Vulnerable soils that easily become impermeable and are thus prone to **desiccation**.

In other words, in arid regions, a whole set of water scarcity modes can be identified, each impacting negatively on the overall economic developmental capacity of the state. Falkenmark (1994:18) identifies four major water scarcity modes that impact on economic activities. These are:

- **Mode "A"** characterized by a lack of 'green water' and manifested as a short growing season. This can be found in the fringes around the Okavango Delta.

- **Mode "B"** characterized by intermittent droughts. This happens in the Kalahari in general and around the fringes of the Okavango Delta.

- **Mode "C"** characterized by anthropogenic desiccation of the landscape because of soil vulnerability. This is particularly relevant to the seasonal wetlands and surrounding grasslands of the Okavango Delta.

- **Mode "D"** characterized by a lack of 'blue water' (endogenous plus exogenous) resulting in anthropogenically induced 'water stress' or 'chronic scarcity' resulting from increased population pressure. This is particularly relevant along the panhandle and around the distil end of the Okavango Delta.

A model can be generated from the understanding of the above water-scarcity modes. This is presented as Figure 5. The main threats that develop as a combined effect of the four parallel forms of environmental vulnerability are shown as boxes in the illustration.

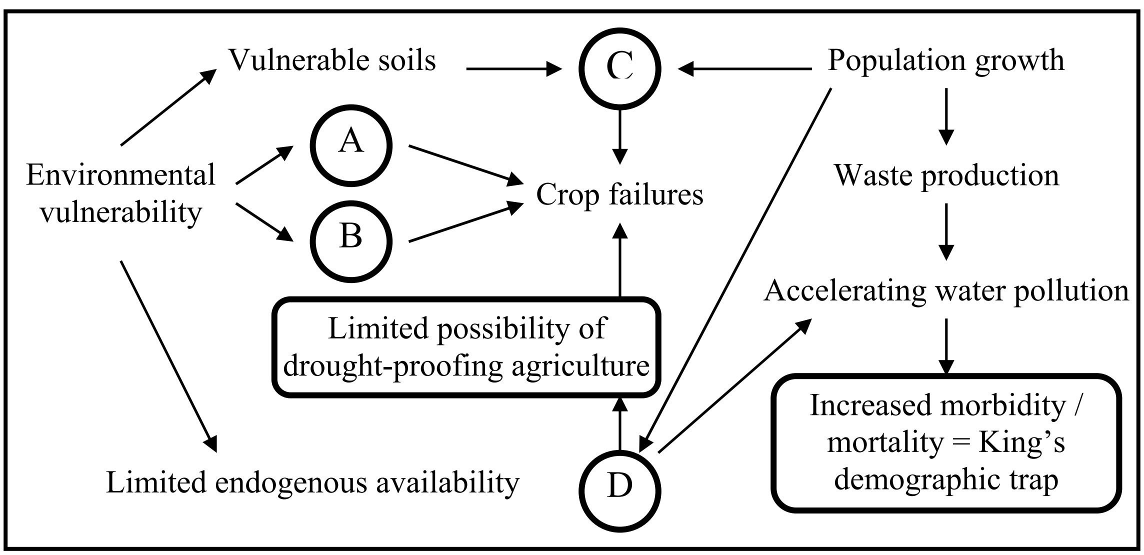

Figure 5. Falkenmark's model showing the main threats which develop as a result of the combined effect of the four modes of water-scarcity (Falkenmark, 1994:20).

The first two types, Modes "A" and "B" are climate-related and should be referred to as problematic environmental preconditions. The third, Mode "C", is the result of vulnerable soils, and is exacerbated by rapidly increasing population pressures within an environmentally sensitive landscape. The last, Mode "D", is a population-driven scarcity and as such will escalate in direct proportion to the number of new persons needing to exist off the available water within the given landscape. Modes "C" and "D" are particularly relevant to the Okavango Delta. This again illustrates the usefulness of the concept of a 'threshold' beyond which sustainability is no longer possible, because if the threshold can be adequately identified before being crossed, the problem can be managed proactively.

Today, Modes "A", "B" and "C" are a common combination over large portions of sub-Saharan Africa and India, accounting for the declining food productivity levels that are evident. In this context, the main risk to society is related to crop failure, which in turn is exacerbated as land desiccation proceeds (Falkenmark, 1994:18). This is what is often loosely referred to as 'desertification', which can be said to exist currently over large parts of the Kalahari, due in this specific case to cattle ranching. This in turn is placing pressure on the Okavango Delta, which is seen to be the last remaining source of fertility and potential prosperity in an otherwise harsh environment.

<u>Theoretical Consideration # 4</u>: Understanding the hydropolitical relevance of **riparian position** within an overall river basin configuration.

A state may receive its total water available from a number of sources. These consist of:

- **Endogenous water** can be understood in hydropolitical terms as being precipitation falling on the territory under the direct sovereign control of the state concerned.

- **Exogenous water** can be understood in hydropolitical terms as originating from aquifers and rivers that are outside of the sovereign control of the state in question and therefore being politically vulnerable.

Thus, in hydropolitical terms, an important variable is that relating to the relative riparian position of a given state within an international river basin. This is in keeping with Buzan's view (1991:242) that a state needs access to the means necessary for their survival. This is illustrated by the fact that a component of the overall water available to any given downstream riparian state is that portion referred to as the 'exogenous' supply, which originates in or flows through an upstream riparian state. Because the downstream riparian is largely at the mercy of the higher order upstream riparian state, both in terms of quantity of water consumed by the upstream user, and in terms of the quality of the water left for the lower order riparian to use, there is an inherent **conflict generating capacity** that is directly linked to this relative spatial position. This is pertinent to an understanding of the overall hydropolitical dynamics of the Okavango Basin.

In this regard, Lowi (1990:377-8) notes that the factor that will almost always invariably lead states to seek technical cooperative arrangements (at the international level), is that of acute need for water resources and/or dependence on a specific shared body of water. The failure to establish a water-sharing regime would threaten the continued survival of the state concerned. This is the situation that Botswana finds itself in at present regarding the Okavango Basin. The opposite also holds true, according to Lowi (1990:379). If a riparian state is not in need of access to the water supply, or if it has a higher order riparian position within a given basin, it will have little, if any, incentive to enter a basin wide regime. This is the situation that is applicable to Angola (and in certain circumstances Namibia) regarding the Okavango Basin. In this case the upstream riparians will have to either be coerced, or induced, into co-operating. Riparian position thus has a fundamental impact on the policy options available to states in arid regions.

Within the context of the Okavango Basin, Botswana is arguably the most vulnerable state. Botswana would thus be expected to establish and maintain a basin-wide regime. Namibia on the other hand would probably stay within a regime if they benefited directly as a result, but would likely move outside of that regime if it restricted what Namibia perceived their strategic options to be. Angola would have the least to gain from participating in a basin-wide regime, but could use this position of hydropolitical strength to negotiate favorable conditions for itself that may not be directly related to the Okavango Basin.

Falkenmark (1994:22) notes that the two sources of 'blue water' (endogenous and exogenous) may exist in different combinations expressed in terms of their sources of origin. Table 1 is a matrix showing the effect that various combinations of exogenous and endogenous water can have on the overall problems that prevail. Typical problem patterns vary according to the position on the matrix. Water scarcity problems relating to both 'green water' and 'blue water' uses are at their largest in the top left corner (square 1). Upstream/downstream rivalry is at its most pronounced in the top right position (square 3), which is where both Botswana and Namibia are located.

	EXOGENOUS WATER SOURCE LOW	EXOGENOUS WATER SOURCE MEDIUM	EXOGENOUS WATER SOURCE LARGE
ENDOGENOUS WATER SOURCE SMALL	Saudi Arabia Australia Tunisia Libya (1)	Niger Iraq Pakistan (2)	Mauritania Egypt **Botswana** **Namibia** (3)
ENDOGENOUS WATER SOURCE MEDIUM	China Spain Mexico (4)	Paraguay (5)	Gambia (6)
ENDOGENOUS WATER SOURCE LARGE	Norway Colombia (7)	Yugoslavia Uruguay Congo (8)	Hungary Netherlands (9)

Table 1. Matrix showing the different combinations of water supply as a function of endogenous and exogenous water and the resultant effect on conflict generating capacity (after Falkenmark, 1994:23).

Besides more direct water scarcity manifestations, a range of **controversial problems** arise, driven by the need of a society to mobilize increasing amounts of water (Falkenmark, 1994:23). There are two broad types of problems envisaged:

- **Seasonality-related problems** which are typically overcome by the construction of large impoundments. Conflict here centers on the inundation of land previously used for other purposes. The litigation resulting from the loss of diamond mining concessions as the result of the inundation of the Katse Dam as part of the Lesotho Highlands Water Scheme is an example. Another example from Southern Africa is the Epupa Falls Dam that will flood Himba ancestral burial grounds. The conflict between the side effects of the dam on the one hand, and the potential benefits to the downstream users on the other hand, as a result of the construction, generates this type of debate.

- The **spatial distribution of human settlement** patterns call for a redistribution of water from water-rich areas to support the activities of humans in more arid regions. Examples here are the North-South Carrier in Botswana, the Matabele-Zambezi-Water-Project (MZWP) in Zimbabwe and various Inter-Basin Transfers (IBTs) in South Africa. The side effects of such projects make them controversial.

Table 2 is a matrix showing various types of conflict or controversy that can be expected to arise from a given combination of endogenous and exogenous water supplies.

TYPE OF CONTROVERSY	MAINLY ENDOGENOUS SUPPLY		MAINLY EXOGENOUS SUPPLY	
	SQUARE 1 ARID	SQUARE 2 HUMID	SQUARE 1 ARID	SQUARE 2 HUMID
Scarcity related Upstream/Downstream			Ethiopia/Egypt **Okavango** Lesotho/RSA	
‘Green’/‘Blue’	RSA		RSA/Swaziland	
Quality related Local		Poland/toxic Sweden/Nitrate		
Regional	India	Europe & North America/ acidification	Jordan	Rhine
Project related			Senegal River Assuan Narmada Epupa Falls	
Coping - storage			Yangtze/Beijing	
- transfer	Mexico			
- urban/rural	India			
Hydropower		Three Gorges China	**Popa Rapids Namibia**	Danube

Table 2. Examples of different categories of water disputes for different positions on the matrix in Table 1.

Falkenmark (1994:25) notes that a seldom-discussed mode of water competition is the **'green'/'blue' competition**. This is likely to arise in relation to the demand for an increase in biomass production as the result of population growth. In other words, policy options will be increasingly politicized as they will entail a hard choice between biomass production, which will return 'green water' to the atmosphere and thus be lost to the overall water availability, and 'blue water' production which depends on the rainwater surplus left to feed aquifers and rivers. Examples of this can be found in Australia, where the city of Melbourne wants the forestry industry to accept longer rotation periods in order to reduce 'green water' consumption, thus leaving more 'blue water' available to the city. A Southern African example is the dispute between Swaziland and South Africa. Swaziland, the downstream riparian, is asking South Africa (the higher order riparian) to limit the 'green water' consumption resulting from commercial agriculture and forestry, which is reducing the flow of water available downstream. In the Middle East an example is the conflict over access to the aquifers beneath the West Bank, where the issue is basically the sharing of water for Palestinian biomass production, versus the supply of water to the coastal cities of Israel (Falkenmark, 1994:26).

Competition between urban and rural areas is referred to as being "project related" in Table 2. This is driven by the expansion of the urban environment in many arid zone states due to rapid industrialization. This introduces conflicts between the city activities and competing water needs in the rural areas. The proposed Popa Rapids hydropower scheme being planned by Namibia will probably fall into this "project related" category, as the choice of project is possibly the least environmentally sound.

Botswana has 94 % of its total surface water supply originating outside its borders (Gleick, 1993:108) placing it on a par with Egypt that obtains 97% exogenously. This makes Botswana extremely vulnerable to the actions of higher order upstream riparian states. In certain river basins, such as the Okavango, Botswana is in a low order riparian position relative to Angola and Namibia. In the Limpopo Basin, Botswana is an upstream riparian relative to South Africa. In the Zambezi Basin, Botswana has only limited access to the basin, but is in an upstream position relative to Zimbabwe. These factors dictate the overall policy options open to Botswana at a strategic level. This is why Botswana is such a valuable hydropolitical case study as it illustrates various combinations of conditions. Zimbabwe on the other hand, is a lower order riparian to Botswana on both the Limpopo and Zambezi Basins.

SIX STRATEGIC DEVELOPMENTAL ISSUES:

Having noted the four major policy-related theoretical considerations that apply to states in arid regions, it now becomes possible to view the six major strategic developmental issues that the author believes currently confront the integrity of the Okavango Delta. Significantly, three of these strategic issues (1-3) are located upstream of Botswana, away from the direct control of that state. This provides a classic illustration of key hydropolitical principles. Two of them are directly applicable to Botswana (issues 4 & 5) whereas issue 6 is relevant to the entire basin in general, but also to the Okavango Delta in particular.

Strategic Developmental Issue # 1: The first long-term strategic issue is related to the **development of Angola**. As has been shown in terms of hydropolitical theory, the upstream riparian state is in a strong position as it controls the headwaters of an international drainage basin. Angola has been in a state of civil war for a number of decades. While this has been devastating in both human and economic development terms, it has meant that the headwaters of the Okavango Basin have remained relatively undeveloped and near pristine. Ironically, the peace dividend in Angola will probably have three major downstream impacts. These are:

- The first relates to **water quality**. Angola is an agriculturally viable state that is blessed with an abundance of water, fertile soils and a good climate. Agricultural development is likely to result in the leaching of agro-chemicals into the aquatic system. Extensive agriculture in the predominantly sandy soils of the catchment could introduce phosphates and nitrates which in turn could disrupt the balance between different plant communities in the Delta (McCarthy & Ellery, 1993:8). As previously noted the Delta region is specifically sensitive to this, being oligotrophic in its natural state. The introduction of leached fertilizers would probably lead to eutrophication of the water downstream, impacting profoundly on the structure and functioning of the ecosystem (Ellery & McCarthy, 1994:166).

- The second relates to **water quantity**. Abstraction of water in Angola for either irrigation or industrial purposes will reduce the overall volume available for downstream use. This is where the usefulness of the 'blue/green' water concept comes in however. Abstraction of 'blue water' by Angola will impact less in terms of volume, whereas abstraction of 'green water' will greatly affect the flow. The reason is that 'green water' is largely lost as transpiration, whereas 'blue water' can be recycled back to the system, albeit with possible loss of quality.

- The third relates to **siltation**. As noted previously, the Okavango system has a very low suspended solids load. Agricultural practices upstream could result in greater runoff with a direct increase in siltation. While siltation is an important natural dynamic within the overall aquatic system, it must be noted that this depends on a specific type of silt load to function normally.

Strategic Developmental Issue # 2: Namibia is an extremely arid country, similar in many respects to Botswana. One of the only permanent rivers that traverse Namibian soil with any degree of reliability is the Okavango. There is a plan to construct a **pipeline from the Okavango River** at Rundu to supply water into the Eastern National Water Carrier (ENWC) at Grootfontein. The initial planning is to abstract 20 million m^3 / yr^{-1}, which corresponds to about 0,2% of the mean annual flow (Ramberg, 1997b:129). This level of abstraction is planned to triple by the year 2003 (Turton, 1998a:185). A 250km pipeline is being developed that will link the Okavango to Grootfontein, where it will join the existing link to Windhoek provided by the ENWC. Namibia is reported as being, "determined to go ahead with the pipeline", threatening to take the matter to the ICJ for a ruling on their legal riparian abstraction rights if necessary (Electronic Mail & Guardian, 28 January 1997).

- Hydrological models indicate that there is a relationship between the reduction of the base flow and **loss of wetland**. This is reported by Ramberg (1997b:127) to be in the order of 1:3. Thus the planned abstraction by Namibia would result in the loss of about 150 km^2 of wetland along the fringe of the swamps, which is where the local people depend on the seasonal flooding to support their largely subsistence livelihoods.

- This abstraction by Namibia is virtually unavoidable as Namibia is in dire need of the water. It is also acceptable within international law and supported by the SADC Protocol on Shared Watercourse Systems that a state may utilize the water to which it is a riparian. Thus Namibian officials may view the regime created by **OKACOM as being excessively restrictive** and may thus choose not to fully support this.

<u>Strategic Developmental Issue # 3</u>: As noted above, Namibia is both an upstream riparian state and extremely water scarce. The Namibian Government have announced their intention of developing a **hydroelectric capability at the Popa Rapids** (Ramberg, 1997a). This will result in two specific impacts that need to be considered.

- The development of a hydroelectric capability at Popa Rapids by Namibia will require the construction of a weir (Ramberg, 1997a). This weir will have a **flood attenuation effect**. As previously noted, the existence of seasonal wetlands is directly proportional to the magnitude of the flooding.

- The construction of dams or weirs could lead to the **impoundment of sediment** and hence cause a disruption of the ecological functioning of the Delta (McCarthy & Ellery, 1993:8).

<u>Strategic Developmental Issue # 4</u>: Botswana is also facing a combination of severe water shortage in conjunction with **population pressure**. This is a near-classic example of Mode “D” water-scarcity as conceptualized by Falkenmark and presented in Figure 5. One area where a reasonably large human population exists is along the panhandle. While little has yet appeared in the form of written scientific material, it is known that Botswana has plans to abstract water along the panhandle. This was made evident to the author during a recent fieldtrip to Botswana. Two known pipelines are in the conceptualization phase at present. These originate at the villages of Sepopa and Mohembo. These pumping facilities are being designed to feed water via pipeline to various settlements south west of the panhandle. It must be noted however that the Botswana Department of Water Affairs (DWA) is not yet committed to this project at the time of writing. It is simply an option that is currently being considered and it may still be rejected for strategic reasons. There are three probable consequences of this if the planning is to be implemented. These are:

- Botswana is locked in conflict with Namibia over the Namibian plans to develop the pipeline from Rundu. The Botswana government has used the argument that any water abstraction from upstream of the Delta is going to result in an unacceptable environmental impact downstream. By developing these pipelines, **Botswana is effectively undermining its bargaining position** in an international forum. There is thus a need to sensitize the engineers who are responsible for this planning to the repercussions in international hydropolitical terms. This is a critical strategic implication in the opinion of the author. It also illustrates the existence of a form of 'threshold'. Until recently, engineers from the DWA have been working on problems without needing to understand that the resulting problems may have international repercussions. Suddenly an invisible political threshold is crossed, and what used to be the domain of an ordinary engineer, generating a solution to a specific problem that may be entirely acceptable within normal engineering parameters, has an added dimension – the potential international political repercussions that no known engineering equation accounts for. The existence of the latter now become so significant as to effectively overshadow what would have been a feasible project when viewed from a narrow engineering perspective. This is abstract however, and difficult to quantify. Because engineers work in absolute terms, they remain unconvinced of the existence of a vaguely measurable 'threshold' and they consequently seem not to be able to grasp the relevance of these issues, becoming exasperated instead by the perceived meddling in their affairs by outsiders.

- These pipelines, albeit relatively small in terms of the planned volume to be abstracted, will **reduce the overall inflow** to the Delta nonetheless. This will increase the environmental pressure already being felt in the Delta.

- By securing a predictable supply of water, the existing settlements are likely to **attract more people** who are being forced to move away from the otherwise harshly arid conditions that prevail elsewhere (Modes "A" & "B" water-scarcity) and who could be loosely described as being environmental refugees. These "refugees" will squat on the only land available, which is normally the marginal land that has already been degraded (Mode "C" water-scarcity) and thus is not being used by the local inhabitants anymore. There is likely to be an increase in population as a result, which in turn will place more pressure of the environment (Mode "D" water-scarcity). One form of environmental pressure will be seen as an increase in nutrients going back into the river as the result of human-induced effluent.

There are also plans to abstract water from downstream of the Delta. It was noted (Ramberg, 1998) that any down-stream abstraction is not likely to be problematic in ecological terms, and will not affect the overall sustainability of the Delta. The author has noted the following three aspects that need to be individually highlighted however.

- There are a plethora of pumping facilities currently to be seen around Maun. Most are small, catering for private water needs. There are some larger systems however. The author noted a new pipeline being laid from Maun to a village on the road to Shorobe. One cannot deny that the local population needs these facilities. However, the existence of a more secure water supply will attract a **larger permanent population**, resulting in Modes "C" & "D" water-scarcity. The value of the spiral conceptualized by Falkenmark that was illustrated in Figure 3 now becomes highly relevant.

- The overall **water supply situation for the town of Maun** is also problematic. Because of the rapid growth of Maun, the sub-area to which it belongs has shown a marked increase in population over time. For example, Maun accounted for 7.0% in 1981, growing to a figure of 55.1% in 1993. As much as 48.1% of the total impact area population live in Maun itself. The Maun sub-area contained 23.4% of the total population of Ngamiland and Central Boteti in 1993 (Scudder *et al.,* 1993:444). Projected water demand for Maun is 4 million m^3/yr^{-1} for the year 2012 as determined by Snowy Mountain Engineering Corporation (SMEC) (Scudder *et al.,* 1993:124). An alternative figure of 3 million m^3/yr^{-1} for the same year was calculated by the International Union for the Conservation of Nature (IUCN) task team (Scudder *et al.,* 1993:124). The latter figure assumes that consumption would be held at 150 l/p/d for house connections by means of tariff structures. Conjunctive use of surface and ground water is planned. In terms of the IUCN analysis, during the three driest consecutive years groundwater would have to be abstracted at a rate of 2.30 million m^3/yr^{-1} (Scudder *et al.,* 1993:169-70), with the rest coming from the Thamalakane River.

- The increased human pressure in the Okavango Delta can result in **eutrophication** of the water. This is already evident in patches around Maun. The concentration of people increases this risk. Tourists occupying camps in the Delta are presenting a specific risk. Nutrients found in soaps for example are finding their way back into the aquatic system. Ramberg (1997a) has determined that each tourist lodge results in a satellite village housing employees at a ratio of 5-10 times the population of the lodge itself. Their effluent is also entering the aquatic environment.

<u>Strategic Developmental Issue # 5</u>: One of the major sources of wealth in Botswana is derived from **cattle ranching**. This is placing heavy pressure on the environment.

- Overgrazing, especially on the floodplain, may reduce the transpiration efficiency and enhance the capillary evaporation of water. This in turn is likely to cause an increase in **salinization of the soils** (McCarthy & Ellery, 1993:8). This is an example of some of the dynamics of Mode "C" water-scarcity at work.

- One of the natural limiting factors for cattle ranching is the existence of **tsetse flies**. This has resulted in heavy spraying of Dieldrin, DDT and Endosulphan over an extended period of time (Pearce, 1993:28). These chemicals are thus present in the overall aquatic system.

- The existence of Bovine Pleru-Pneumonia and other cattle diseases has resulted in the development of **veterinary control fences** (VCF) across large tracts of the Kalahari and into the Okavango Delta itself (Conservation International, 1996). While this has meant that Botswana beef can now comply with stringent European Union health requirements, it has also meant that a major interference to natural animal migrations between the Okavango Delta and the Kalahari has resulted. These fences have caused significant game mortality as a result (Scudder *et al.,* 1993:74).

- Many cattle now die of old age as the national herd is larger than is required to meet the domestic and international market. The **system of subsidies** has resulted in the desire to fill all of the land with ever more cattle, which in turn consume everything around them (Pearce, 1993:26). The author has noted the impact of this in his own lifetime with documented photographic evidence of the results. This is another example of one of the dynamics of Mode "C" water-scarcity at work.

<u>Strategic Developmental Issue # 6</u>: **Human encroachment** is an inevitable result of the increase in population in the face of water scarcity. This can be understood as being an example of one of the dynamics of Mode "D" water-scarcity at work. Within the Delta region, this has placed considerable pressure on the margins of the seasonal wetlands. The most important natural resources that result from a human use perspective are wildlife, fish, reeds, thatching grass, trees, veld products (tubers etc) and tourism (Ramberg, 1997a). The planned abstraction of water upstream is likely to result in the following dual dynamic:

- On the one hand, abstraction will reduce the water quality and quantity, resulting in a **depleted resource base**. This can be understood as being a future constraint to development. This will impact heavily on the fringes of the swamp areas. Significantly, this is also where future ecological refugees are likely to settle.

- It is precisely along these fringes that human settlements are at their heaviest. In this regard, the availability of water acts as a **development magnet**, attracting ever more people. This can be understood in terms of being a population-pull factor.

With growing demands on a marginal environment, recurring droughts become increasingly severe in their impact (Mode "B" water scarcity). The risk of a more permanent desertification in parts of the Kalahari (Mode "C" water-scarcity) is thus a very real one (Cooke, 1985:82). This can be regarded as being a **population-push factor**. Thus the provision of secure water will become a **population-pull factor**, and the migration of people can be realistically expected as a direct result. The significance of this can be best understood in terms of a major drought scenario. Under such conditions, the permanent settlements will be under pressure of water shortages because of the drought. They will then suddenly become the focal point for migrants, stimulating the demand curve beyond the capability of the system to supply. Catastrophic failure of the ecosystem will therefore result and a significant 'threshold' will have been crossed, probably forever. The strategic significance of understanding 'thresholds' is thus abundantly apparent yet again.

<u>CURRENT STATE OF PLAY:</u>

Having noted the significance of theoretical models and concepts to the overall development debate, specifically how these apply to the six strategic developmental issues that have been highlighted, it now becomes necessary to discuss what the current state of play is before determining what solutions are available. In the opinion of the author, there are three major factors that serve as useful indicators of the way things currently stand within the case study area. These are:

<u>Factor # 1</u>: As a result of the fact that Namibia has announced its intention of developing the Okavango Pipeline, the government of Botswana tried to counteract these plans by applying to UNESCO to have the Okavango Delta declared a ***Ramsar Site***, thereby hoping to increase the international pressure on Namibia (Ramberg, 1997b). Whilst this may be regarded as a resounding victory for conservationists, it may also have resulted in the fact that Botswana has effectively limited its own strategic options in the process. In reality, this is a classic example of being both a double-edged sword as well as a subtle but significant 'threshold'.

- This has **politicized the issue** internationally. It will probably mean that Botswana will be able to mobilize international support, funding and research in an effort to prevent Namibia from implementing these plans. This is likely to result in a highly emotive public debate, as there is a clear dichotomy between Namibia's legal position and its probable moral position. In terms of this debate Botswana is likely to be shown in a positive light and Namibia shown in a negative light if it pushes ahead with its plans.

- On the other hand, this also means that Botswana has painted itself into a corner. This illustrates the effects of having crossed a significant **political 'threshold'**. The public sentiment that is likely to be negative towards Namibia is just as likely to become negative towards Botswana if the proposed pipelines are developed along the panhandle. It is known for example that NGO's are already mobilizing around this specific issue at the time of writing.

<u>Factor # 2</u>: Against this background, there are grave doubts that **OKACOM is failing** (Ramberg, 1997b). Within the OKACOM configuration, the hydropolitical aspects that have been raised under the discussion on theoretical considerations can be used to plot the likely courses of action that each of the actors will take.

- In this regard, it is abundantly clear that **Botswana** is in the weakest position. It is the downstream riparian and it has a critical need for the resource. Botswana's interests will therefore best be served by reviving OKACOM and pushing for the creation of an effective basin-wide regime. Botswana really has the most limited range of strategic options available.

- **Namibia** on the other has a wider range of strategic options available. Namibia can invoke the legal principles contained within the Helsinki Rules and supported by the

SADC Protocol on Shared Watercourse Systems, and claim the right of abstraction. This will be legally correct. Given the fact that this will impact negatively on a *Ramsar Site*, what is legally right may in fact be seen to be morally wrong. This makes for a classic dilemma. This is likely to result in a highly emotive debate, along the lines of the current public outcry against South Africa over the fate of the baby elephants that were saved from culling in the Tuli Block of Botswana. Namibia is likely to feel the negative aspects of this debate as the result of the proposed pipeline, and possibly even more so over the proposed hydroelectric scheme at Popa Falls. Having said this, Namibia is also very vulnerable to the long-term actions of Angola. Siltation and chemical pollution of the water can effect Namibia almost as badly as Botswana. Therefore, Namibia may wish to stay within the confines of OKACOM, but with specific clauses in the final agreement that favour their interests directly.

- **Angola** has the least incentive to co-operate within the confines of OKACOM. In fact, officials in Angola can even see a fully functioning OKACOM as being detrimental to their own perceptions of what their long-term best interests may be. Consequently, it can be anticipated that Angola will have to be induced to co-operate.

In short, OKACOM is set to become the forum for some fairly intense hydropolitical interaction in future. By documenting these events as they happen, a valuable insight into the hydropolitical dynamics between states in arid regions will result in the opinion of the author.

<u>Factor # 3</u>: The current pattern of conflict dynamics in the Okavango Basin is based on the **zero-sum principle**. This means that the conflict potential is likely to be extremely high as it is based on a fundamental dynamic of win-lose. An important aspect of this zero-sum paradigm is the fact that it is closely linked with the perceptions that each decision-maker may have. There is thus a clear-cut distinction that needs to be made between realities and perceptions of those realities. In fact, a careful analysis of potential benefits versus potential costs for each of the role-players may even reveal that the prevailing paradigm is that of a lose-lose configuration. This in fact may even be the best strategy open to Botswana as the most needy actor in the overall configuration. By convincing the other actors that their actions are actually being detrimental to themselves, a more cooperative spirit could be generated. This could result in a paradigm shift from a win-lose model to that of a more cooperative win-win approach. This will take time and effort to achieve.

- **Information** is therefore going to play a decisive role in the overall interaction. There is consequently an important role to play for researchers, consultants, NGO's and the media. Botswana can use the Okavango Research Centre in Maun to advantage here.

- **Communication** is also going to become increasingly important. A major target for this communication will probably be to convince the upstream riparians that a win-win cooperative paradigm is a better one to adopt.

In summary, the prevailing win-lose paradigm will have to change to one of win-win if OKACOM is ever going to succeed. This will take time and effort, with communication playing a crucial role.

SOLUTIONS:

Having noted the overall factors, issues, theoretical considerations and dynamics that prevail in the Okavango Basin, it now becomes possible to suggest four solutions to the problems.

Solution # 1: Because one of the underlying features of the overall Okavango problem is related to competition over ever decreasing resources, it becomes abundantly clear that an **effective multilateral structure** needs to exist. There are two aspects that are relevant. These are mutually supportive of one another.

- There is already a multilateral structure in the form of **SADC**. In terms of SADC, there is the SADC Protocol on Shared Watercourse Systems, which already exists. In terms of Article 3 of this instrument, River Basin Commissions are required to be set up between member states.

- **OKACOM** already exists but is not functioning well. Clearly it makes the most sense to revitalize OKACOM and to further legitimize it by means of the SADC Protocol.

The best way to reestablish OKACOM is probably by means of diplomatic interchange at a level higher than the technical working group in the opinion of the author. It cannot only be left to technical commissions as preliminary research that has been conducted by the author suggests that "there is an underlying fear that River Basin Commissions may eventually erode the sovereignty of the state, so officials do not allow cooperation to develop to a level beyond the minimum that is absolutely necessary" (Turton, 1999b). As already noted, communication will play an important role in this regard, creating the right climate for the diplomatic interchange by empowering the decision-makers with the relevant knowledge that they will need in order to be effective.

Solution # 2: As has been noted above, there is a prevailing **zero-sum paradigm** in existence. Because this is inherently conflictual in nature, there is a need to change this to a cooperative approach based on the benefits of win-win principles. This takes time as it is based at least in part on prevailing human attitudes.

- Attitudes can be changed if **communication** is effectively used. The purpose of this communication must be to inform the decision-makers of the costs of the prevailing zero-sum paradigm and the benefits of a cooperative paradigm.

- The inherent benefits of **diplomatic interchange** can also be brought to bear. In this regard, political allies can be used to also raise the issue in the appropriate international political fora. This also illustrates the relative advantage of raising the issue of the revitalization of OKACOM at the political level rather than at the technical level.

The long-term objective of this whole series of interactions is to change the prevailing paradigm to a cooperative one. This has lower conflict potential and increases the regional security by offering guarantees to all of the participants. While each actor may not get exactly what they feel they want, in the final analysis they can probably get what they effectively need for survival in the process.

Solution # 3: There is an overarching need to begin to balance the **developmental aspirations** of each state against the realistic developmental potential of those states. The operative word in this regard is "balance". This is needed between the following:

- By introducing the notion of the **water landscape** at the policy-making level, the issue is no longer one of man versus the environment as already noted. In terms of this concept, man is an integral part of his environment, and the water landscape becomes the life-support system that is needed for continued survival. Part of this solution is then linked to the revenue that is generated by tourism. It could be argued that wildlife is a far more efficient means of harnessing the natural environment and converting it to an economic asset than farming is in arid regions.

- Critical to this whole balancing act is the need to expand the policy-making support system available to states. Unquestionably, the major driving force behind all of the development-related problems that have been highlighted in this paper, is uncontrolled **population growth**. Therefore, as long as this population-factor is not being dealt with at the policy-making level, the final result will almost always be unsustainability. This is illustrated in Figure 6.

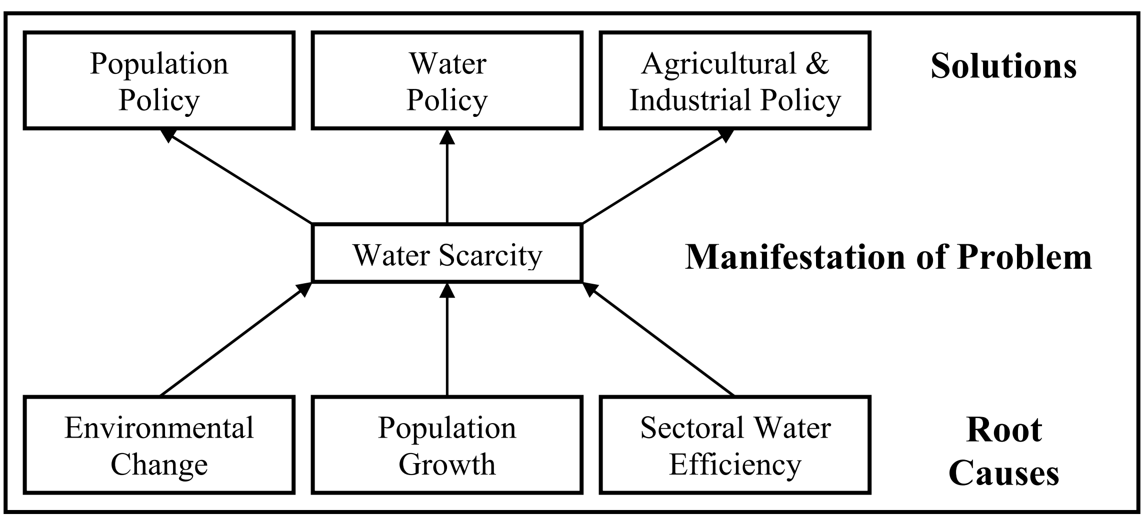

Figure 6. Schematic representation of the actual root causes of the water-scarcity problem and consequent solutions that ought to be considered by policy-makers in developing states within arid-regions (Turton, 1998a:258; 1998b).

Previous research that has been done by the author shows that water scarcity is not the actual problem, but is rather the manifestation of the interaction between three specific root causes (Turton, 1998a:258; 1998b). These root causes are environmental change, population growth and the allocation of water within an economy to specific sectoral uses. In this regard, the author has suggested the linkage of policy to effectively deal with this expanded view of water-scarcity in arid regions as shown in Figure 6. In fact, if population growth was under control, it could be argued that there is no water shortage in Botswana, and that the existing scarcities could be managed by a combination of water demand strategies and improved sectoral allocation within the economy.

- An important component of the need to balance the developmental aspirations of each role-player is linked to the **national interest** of each state. At present, each state seems to be viewing their own national interest from a very narrow perspective. This is what is essentially driving the zero-sum dynamics within the Okavango Basin. There are really three important components to this that need to be specifically highlighted.

    1) A key component of national interest is the **perception that the individual policy-maker has** of what this interest is or should be. Because perceptions play such an important role, the importance of communication again comes to the fore. This communication should be designed to change the perception of the national interest over time.

    2) Another key component is the fact that the **policy-maker is not necessarily a water specialist**. In fact, the policy-maker tends to be a politician who is elected to office for a period of time and then departs. While this is not true in all cases (Asmal, 1998), it certainly is the case much of the time.

    3) The people that provide continuity are usually the technical staff from the respective Departments of Water Affairs. They also have an extremely narrow focus, being guided by the engineering related dimensions of their normal work. The proposed panhandle pipelines are an example of this. There is thus a need to expand this technical staff to include specialists that can adopt a **multidisciplinary approach**. This is necessary once a critical threshold has been crossed - that of the politicization of water at the international level - as has been the recent case with the Okavango Delta.

Solution # 4: **Capacity building** is an obvious solution. Leif Ohlsson (1998; 1999) has done some pioneering work in this regard. It is the inability of developing states to innovate in the face of complex challenges, which causes them to fail (Barbier & Homer-Dixon, 1996). It has been shown that there are many aspects to the capacity of states, which manifests when that state tries to deal with water scarcity (Turton, 1999d). This is relevant for most of the states in the Okavango Basin, albeit in varying degrees.

- There is a critical shortage of **intellectual capacity** in the Southern African water sector, specifically regarding the social sciences. This lack of capacity is what Ohlsson refers to as a 'social resource scarcity' (1998:1) or 'lack of social adaptive capacity' (1998:8). It is precisely the existence of this lack of adaptive capacity within the Southern African water sector that makes cooperation between all role-players so vital (Turton, 1999b). The development of this intellectual capacity should be focussed on incorporating indigenous knowledge systems and understanding the unique problems that confront developing states in arid regions. This means that intellectual capacity that originates from the wetter parts of the developed world is not necessarily entirely relevant to the unique problems that exist in the arid, under developed regions of the world (Turton, 1998c). The Okavango Research Centre in Maun can play a pivotal role in this regard and deserves to be encouraged in their current scientific endeavors.

    1) Article 5 of the **SADC Protocol** on Shared Watercourse Systems provides for the collection, storage, analysis and dissemination of data relevant to the integrated development of the resource, along with the design of relevant research programs.

    2) At present, each state is trying to develop this intellectual capacity themselves, almost in competition with one another. This is self-defeating in the opinion of the author. What intellectual capacity exists, should be **shared for the common good**. This will clearly have to involve a paradigm shift towards a more cooperative basis of interaction. If not, then the shortage of intellectual capacity will become a definite element of social resource scarcity as conceptualized by Ohlsson in the opinion of the author.

- There is also a critical lack of **institutional capacity** within the Southern African water sector. This will have to be specifically addressed.

    1) There is a **maldistribution of institutional capacity** within the Southern African region. Within the Okavango Basin, Botswana probably has the most highly developed institutional capacity, although Namibia is probably not far behind. Even then, the capacity of both of these states is really limited when compared with other parts of the world. Angola has very limited institutional capacity indeed.

    2) The **SADC Protocol** on Shared watercourse Systems calls for the establishment of institutional capacity, but leaves it up to the individual states concerned to establish, staff and fund these institutions. For this reason, institutional capacity at a regional level is somewhat stunted, being limited at this stage to the SADC Environment and Land Management Sector (ELMS).

- All capacity building efforts are highly dependent on the availability of **financial capacity**. Without sufficient financial capacity, other aspects of capacity building are rendered ineffective (Turton, 1999d). As with the other forms of capacity, this is also seriously limited at present.

1) Article six of the **SADC Protocol** on Shared Watercourse Systems notes that the financial framework for the various River Basin Management Institutions shall be annexed to the Protocol once it has been finalized. This hampers the implementation of the Protocol, as without a budgetary base, the institutional structures cannot be effectively established (Turton, 1998a:57).

RESEARCH NEEDS:

From the preceding discussion it becomes evident that there is a pressing need for well-coordinated applied research. The following are areas that would be beneficial in the opinion of the author:

- The whole academic discipline of **hydropolitics is in its infantile stage**. There is thus a pressing need to develop this discipline further as a matter of some priority. What is needed is an emphasis on the following:

  1) There is a need to **define key concepts** that are the critical components of any scientific endeavor.

  2) Once the concepts have been defined, there is a need to develop an understanding of the **relationships that these concepts have** with one another in terms of being either independent or dependent variables.

  3) Once the variables have been isolated and their relationships determined, then there is a need to **develop hydropolitical models** by understanding how these variables (and other sets of variables) relate to each other.

  4) Finally, there is a need to study the models that are derived from different regional settings in order to determine whether there are commonalties or universal truths that exist. In other words, a **paradigm needs to be developed** over time. It is possible that the hydropolitical dynamics that exist within a given regional setting are highly dependent on specific local conditions or variables. In this case universality may not be attainable. Where universal truths have been isolated, they may be found to be so vague as to be almost meaningless. This needs to be explored further.

- The study of hydropolitics shows how interconnected the problems are. There is thus a need to encourage **interdisciplinary research**. The danger of a multidisciplinary approach is that the final study can be treated with suspicion or disdain by the intellectual purists. The need still remains for such an approach however.

  1) At least one of the elements of this research should be aimed at achieving a **common terminology**.

2) The **relevance of concepts** that are already in use by other disciplines must be determined. For example, the 'inflection point' is essentially an ecological concept. It also has its value to a researcher trying to understand decision-making, as the 'inflection point' becomes one of the decision-making parameters. The problem now becomes related to the operationalization and quantification of this concept. This is currently under way in South Africa because the new National Water Act (36/98) calls for the establishment of the "reserve" which in turn needs an IFR determination to be made of any river before permits can be issued.

3) These concepts can then be **adapted or refined** accordingly as the appropriate hydropolitical models are being developed.

4) One specific case is that of **water demand management**. Work that has been done by the author (Turton, 1999c; 1999d) in this regard suggests that it is highly suited to a multidisciplinary approach as it covers a wide range of complex issues.

- The Okavango Delta case study has shown that '**thresholds**' are relevant. They are extremely difficulty to accurately detect and quantify in reality however. There are a number of types of thresholds that will probably be relevant to a profound understanding of hydropolitics. These are likely to be:

1) **Political thresholds** are subtle but pertinent. The Okavango case study shows that engineers chose to consider the development of a pipeline system along the panhandle. Under normal conditions this would probably be acceptable. The planning is certainly within acceptable engineering parameters. Once the Government of Namibia chose to develop their new Okavango pipeline a political threshold was crossed. The author would argue that this took place when the Government of Botswana chose to register the Okavango Delta as a *Ramsar Site*. The issue at hand was thus elevated from the status of a normal engineering problem, to one with the status of an international political issue. It therefore fell beyond the competence of engineers alone to make the decision concerning the pipeline project, probably for the first time in their living memory.

2) **Population thresholds** are also relevant and possibly easier to quantify. Both Falkenmark, (1989:114) and MacDonald *et al.*, (1990:2.25) note that Gustafsson has determined that a country would have the capacity to be self-sufficient in food production at the subsistence level based on rainfed agriculture if there is a minimum of 1 250 $m^3 / p / yr^{-1}$. Of significance however, this figure does not make any allowance for water availability for either industrial or irrigation demands (Evans, 1995:2.8). After studying the most successful traditional cultivation systems that history had recorded - those of eastern Asia, the Nile River basin and the Netherlands - Vaclav Smil concluded that a threshold level of 0,07 hectares of arable land per person was incapable of feeding their population on a sustainable basis without intensive use of synthetic nitrogen, phosphorous and other technological improvements. This threshold signals the transition to the vulnerability of dependence on extensive modern inputs. The crossing of this

threshold is seen as a permanent event without subsequent expansions in land availability or considerable decrease in population size. Ohlsson (1999) gives a detailed and chilling account of what can happen when this threshold is crossed, as in the recent case of Rwanda.

3) **Ecological thresholds** are known to exist between different phases of ecosystem degradation or reconstruction. Critical thresholds that are hydropolitically relevant relate to ecosystem collapse or possible revitalization.

- Given the existence of tensions between stakeholders, it is necessary to begin to develop a deeper understanding of **conflict resolution** and conflict management.

- As previously noted, the field of **water demand management** is conducive to a multidisciplinary approach. It is also probably one of the most significant issues currently emerging from the water sector in Southern Africa. The importance of this is likely to grow in direct proportion to the increase in water-scarcity. This field of research covers diverse disciplines such as economics, psychology, communications, anthropology, political science and sociology amongst others.

- Given the relevance of population growth within the overall water-scarcity debate, specific research should be targeted at quantifying and mapping out the current and future **migration patterns** of "ecological" or "environmental refugees". Attention in this regard should be given to identifying any 'thresholds' that may suddenly be crossed due to this presumably unplanned, probably drought-induced migration.

CONCLUSION:

This paper has been an attempt to produce a comprehensive document that illustrates the relevance of water within the context of a developing state in an arid region. Suggestions have been made for additional research and the development of relevant intellectual capacity. The material that has been presented suggests that if the ecosystem fails, then it is catastrophic for all of those people that depend on the ecosystem for survival. A valuable lesson can be learned from the Aral Sea in this regard. Botswana has been a highly successful state within an African context. Yet this success could be short-lived unless some really critical strategic issues are adequately addressed. This will require decision-makers that are farsighted and visionary. They will have to be empowered to make the correct decisions by scientists and specialists, probably working in multidisciplinary teams. Crucial to the success of this, will be the fact that a paradigm shift needs to be made away from the existing national interest base towards a more cooperative regional approach. The important aspect to note however is the fact that sustainability means, in its most basic form, that development must take place within the constraints that the environment has posed. This can be achieved once man realizes that he cannot stand alone from the environment, and accepts that he is an integral part of the overall water landscape. In short, it involves a fundamental shift away from the "wild-west" notion of ever expanding boundaries (Wilson, 1998), to the new political economy of the spaceship earth with its life-support provider, the water landscape.

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