Preliminary Evaluation of Kalahari-Karoo Aquifer Conditions
SDC UNESCO Project
Groundwater Resources Governance in Transboundary Aquifers

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1 Background

During the preparatory phase of the SDC Full Size Project “Groundwater Resources Governance in Transboundary Aquifers”, information is to be gathered for the detailed design of the full project. This report, jointly prepared by the local consultants, presents part of this information. As context, a brief description of transboundary aquifer management in the Southern Africa region as a whole is provided. This is followed by a preliminary description of the characteristics of the Kalahari-Karoo transboundary aquifer as well as a stakeholder analysis from each of the three countries sharing the aquifer, namely Botswana, Namibia and South Africa.

2 Groundwater in Southern Africa (SADC)

2.1 Groundwater characteristics

The eastern and northern part of the SADC region may be characterized in terms of its climate as humid tropical and humid equatorial. In the more arid parts, especially southern Angola, Namibia, Botswana and north-western South Africa, and western Zimbabwe, groundwater storages are recharged for the most part by heavy rainfall events that infiltrates through the soil into the underlying layers. In the driest parts, groundwater recharge may even be largely limited to localized line and point sources such as stream beds and dam basins respectively. In these areas, surface water resources are largely ephemeral, and most perennial rivers within these areas receive their recharge from more humid areas. As a result, the groundwater resource has assumed great importance as the principal source of fresh water.

Besides the climatic differences, groundwater occurrence in the region is characterised by a large variety of geological structures that condition the regional hydrogeological settings as illustrated in the Hydro-lithological map for SADC (SADC, 2010 - Figure 1). Approximately 60 to 65% of the region is covered by crystalline rocks with aquifer systems developed in the weathered regolith and in the fractured bedrock. The aquifers developed in these areas are unconfined, locally developed and are not really extensive. In general only modest groundwater supplies can be abstracted sustainably from these aquifers and large scale groundwater well field developments are not feasible.
25 to 30% of the region is covered by major groundwater basins that are aerially extensive and exhibit primary porosity and permeability. These basins include the Permian-Triassic Karoo sedimentary basins that cover large areas in South Africa, Botswana, Zimbabwe, Zambia, Namibia and Angola. Along the coastal areas, especially in Mozambique and Tanzania, extensive Cainozoic coastal plain deposits constitute an exploitable aquifer resource. Similar deposits occur to a lesser extent along the west coast of the region. The Kalahari basin occupies a vast area of unconsolidated aeolian sand, tertiary to recent in age, which potentially forms a huge primary aquifer resource. However, pockets of saline groundwater in the Kalahari have been reported from the more arid areas in Botswana and Namibia, where this unit occurs extensively.

About 10% of the area is covered by areas designated as “complex hydrogeological structures”, such as folded and faulted meta-sedimentary sequences as well as lavas.

Very important for sustainable and also joint utilization of groundwater resources is an understanding of the groundwater recharge mechanisms and their quantification. While there has been some very good local research, a systematic regional understanding is still lacking. According to Beekman and Xu (2003), annual recharge can be averaged at rates varying from less than 1 mm per annum in the most arid parts to more than 60 mm per annum (Figure 2).

In the driest parts, the average annual rate of groundwater recharge, although often fully targeted for abstraction, is a fairly meaningless figure, because aquifers here are probably replenished only by episodic high rainfall events occurring once in a period of decades. In more arid areas there seems little evidence to substantiate the claim that groundwater systems are connected to surface water bodies. Occasionally, though, the groundwater storages are augmented by the streams and rivers that lose water to the underground strata. In humid regions, aquifers tend to be connected to river systems and groundwater becomes a major factor determining base flow.

### 2.2 Groundwater utilization

No reliable statistics on groundwater use in the region are available. However, it is well known that groundwater is the largest water supply source for the domestic water supplies in the region, while it also plays a significant role in stock watering and other uses (see Table 1). Its contribution to total utilisation in the region is estimated at 12% by volume, while in domestic supplies it contributes approximately 20% by volume and 37% by population (Molapo et.al., 2000). This can be compared to 23% that is supplied with surface water. The remaining 40% of the population remains un-served. The largest portion of this backlog in terms of access to improved water sources is in rural areas and here communities largely rely on informal, traditionally developed groundwater sources (i.e. hand dug wells, springs, sand river abstraction). Significantly increasing the coverage of rural water supply in these
areas is fundamental to achieving MDGs. Groundwater will be the principal source to move towards a sustainable supply in most of these backlog areas.

2.3 Groundwater resources management

Groundwater’s overall development role is still poorly understood by many of the region’s decision-makers, resulting in under-utilization and poor management of the important resource. A recent assessment (Braune et al, 2008) found that despite the progress with groundwater utilization and management that has been made in SADC relative to other parts in sub-Saharan Africa, the performance must still be rated as “below expectation” when compared to relevant international best practice. This is the case across the full spectrum of IWRM, in particular the Enabling Environment and Institutional Development. While there are useful developments in terms of management in some member states, the important aspect of national planning for groundwater resources is still generally below expectation.

There appears to be awareness at decision-making level about the importance of groundwater, but this is not yet adequately reflected in policies and practices. Some of the broad conclusions from this assessment were (Braune et al, 2008):

- Despite the inability of bulk water supply solutions to address most of the widespread and diffuse water demand required to meet the remaining water services backlogs, there is still a general bias towards surface water resources in the region;
- There appears to be legislation catering for groundwater in place, but it is often very old and without any harmonization across the region;
- Critical shortcomings appear to be in the organizational framework and the building of institutional capacity for groundwater;
- Major changes in institutional development for water services delivery and IWRM are taking place in SADC, but groundwater’s unique role has not been adequately reflected in this new development, for example in River Basin Organizations and Water User Associations;
- Also, where groundwater is a clear responsibility, institutions have not yet been properly capacitated in terms of their new groundwater responsibility, for example local government;
- The above is reflected in a completely inadequate monitoring and assessment of groundwater resources and a resulting poor attention to groundwater planning at all levels. This is particularly serious for drought risk management in which groundwater resources are to play a critical role;
- A lack of macro-planning for groundwater prevails, as most of the programmes are undertaken on an ad-hoc or crisis-response basis. This is one of the most problematic areas in relation to groundwater development.

The poor information situation was exposed in the SADC Hydrogeological Map project by the large differences in availability and quality of data submitted by the contributing countries. Some countries do not even have a groundwater data base and systematic monitoring of groundwater conditions is only taking place in two or three countries.

As a result of poor management, groundwater infrastructure is often not maintained and groundwater sources are often degraded through pollution and local overuse. The most widespread pollution is from poor sanitation, in both rural and urban areas. Where mining is extensive, e.g. in Zambia, DR Congo and South Africa, it has often caused serious pollution of underground waters. Pollution is exposing communities to serious health threats and gives groundwater a bad name. There are examples of vital water supply sources and even
whole aquifers being abandoned due to pollution and replaced with scarce and expensive piped surface water supplies. Groundwater pollution has become a clear threat to meeting the Millennium Development Goals.

2.4 Transboundary Groundwater Management

The SADC region appears to be well placed to pilot transboundary aquifer management. Formal regional cooperation in the water sector was established in 2000 through a protocol, the Revised Protocol on Shared Watercourses in the Southern Africa Development Community (SADC, 2000). This formal regional roll-out of the international water law initiated by the Helsinki Rules is unique in Africa. The overall objective of the Protocol is to foster closer cooperation for judicious, sustainable and co-ordinated management, protection and utilisation of shared watercourses and advance the SADC agenda of regional integration and poverty alleviation. The main measure in terms of the Protocol is ‘to promote and facilitate the establishment of shared watercourse agreements and shared watercourse institutions for the management of shared watercourses’. Of the 15 major river basins which are shared by two or more nations, 11 have by now some form of institutional framework for shared management, e.g. a Commission or Technical Committee (SADC, 2009).

This high level policy, which fully caters for groundwater, has been translated into action through the Regional Strategic Action Plan for Integrated Water Resources Management (now in Phase III) and a Groundwater Programme as one the components of the integrated action plan (SADC, 2011).

Already in 2000, UNESCO’s International Hydrological Programme (IHP) had established the Internationally Shared Aquifer Resource Management Programme (ISARM) to address groundwater in international water policy and legislation. As part of a number of regional initiatives, an ISARM-SADC became operative in 2007 in a network covering all SADC countries. By 2011 twenty-nine transboundary aquifer systems had been identified and broadly described in the region (Figure 3 - Braune and Xu, 2011). This followed on the summary made by IGRAC in 2005 (Vasak, 2008).

An important groundwater milestone has been the resolution in 2007 by the African Ministers Council on Water (AMCOW), as part of a major Africa Groundwater Initiative, to ‘promote the institutionalisation of groundwater management by river basin organisations to ensure regional ownership of the initiative’. SADC endorsed the AMCOW policy direction and resolved in 2008 at its ‘Groundwater within the SADC IWRM Initiative’ Workshop to ‘pro-actively add groundwater into the programme of activities of the African Network of Basin Organizations (ANBO) and basin organizations. If necessary this could be done through
appropriate sub-commissions to create the dialogue (SADC, 2008). In the same year, the Orange-Senqu River Basin Commission (ORASECOM) became the first river basin commission in SADC to establish a Groundwater Technical Committee.

In 2008 the ISARM-SADC decided on the Kalahari-Karoo aquifer system (basin No. 13 in Fig. 3) within the Orange-Senqu River Basin as the first pilot area in which to test transboundary aquifer management principles. In 2009 SADC recommended at its 3rd SADC Multi-stakeholder Water Dialogue that the UN International Law Commission Draft Articles on The Law of Transboundary Aquifers should be fleshed out within the framework of the SADC Protocol on Shared Watercourses as part of the recommended pilot project. In the same year a groundwater overview study was undertaken by ORASECOM in the Molopo Nossob sub-basins (the sub-basins covering a portion of the pilot TBA system) as part of the first Transboundary Diagnostic Analysis for the Orange-Senqu River Basin (ORASECOM, 2009).

3. Groundwater Conditions within the 3 Countries

3.1 Groundwater conditions within Botswana

Groundwater is a vital resource in Botswana. Many areas of the country are reliant upon it for their water supply needs, be they domestic, agricultural or industrial. Most rural villages are wholly dependent upon borehole water supplies as is currently the mining industry (economically the most important source of income for the country). It has been estimated (DWA 2000 Monitoring Report) that 80% of Botswana’s inhabitants receive their water supply from underground resources, although with the North South Carrier (NSC) now fully operational this figure may have reduced (Botswana National Water Master Plan Review (BNWMPR), 2006). There are more than 25,000 officially registered boreholes in Botswana of which over 10,000 are Government of Botswana (GoB) owned water supply boreholes. The remainder are privately owned boreholes. The number of unregistered boreholes is unknown but could easily be in excess of 5000.

Rainfall is unevenly distributed in Botswana (Figure 4), ranging between 300 mm in the western part of the country to slightly over 600 mm in the northern side. In general, the areas that receive high rainfall tend to have shallow groundwater depth (northern part of the country) compared to those which receive less rainfall (south western part of the country). This may imply limited groundwater recharge in dry areas within the western part of the country (BNWMPR, 2006).

Figure 4 - Rainfall distribution in Botswana
(Source - DEA & CAR, 2006)

Recharge from rainfall events, particularly in the central and west of the country, is only in the order of around 1 mm/yr. In some cases the aquifer receives no recharge at all and the groundwater abstracted is thousands of years old. It is important to note that almost all
groundwater abstraction in Botswana has an element of mining. Abstraction from wellfields generally exceeds the annual recharge rate. As a result the groundwater resources used may never fully recover in future.

3.2 Groundwater conditions within Namibia

Within Namibia surface water availability is closely linked to a rainfall pattern that is extremely inconsistent in both time and space. Only 8% of the country in the extreme northeastern part receives a mean annual rainfall of more than 500 mm per annum, while the extreme western part receives less than 100 mm per annum. Water supply to some of the larger urban centres in Namibia is from dams on ephemeral rivers and inflow into these dams is irregular and unreliable, and evaporation rates in Namibia’s arid climate are high. The only assured surface water supply is limited to the perennial rivers on the northern and southern borders of the country and this water must also be shared with the neighbouring countries.

Namibia is therefore highly dependent on groundwater as the surface water sources in the interior of Namibia are unreliable and over 80% of the geographical area of the country receives its water largely from groundwater. The dependence on groundwater is accentuated during prolonged periods of drought, when much of the surface water tends to dry up. In accordance with the Hydrogeological Map of Namibia, groundwater-producing rock bodies in which borehole yields generally exceed 3 m$^3$h are classified as aquifers. Only 42% of the country overlies aquifers, of which 26% of the area contains porous aquifers and 16% fractured aquifers.

Groundwater studies conducted in Namibia identified a number of important aquifers that are of a transboundary nature, but none of them has yet been studied jointly by the States sharing those aquifers. The southern part of the Kalahari lies in the Lower Orange River Basin and the so-called “Stampriet Artesian Basin” in Namibia is part of a shared aquifer that straddles the border between Botswana, Namibia and South Africa. Internationally the groundwater basin is known as the Kalahari / Karoo Multi-layer Aquifer and for easier clarity from a geographical perspective will be termed the Stampriet Kalahari / Karoo Aquifers. It covers approximately 14% of the Orange-Senqu River Basin.

3.3 Groundwater conditions in South Africa

Over 80% of South Africa is underlain by relatively low-yielding, shallow, weathered and/or fractured-rock aquifer systems. By contrast, appreciable quantities of groundwater can be abstracted at relatively high-rates from dolomitic and quartzitic aquifer systems located in the northern and southern parts of the country, respectively, as well as from a number of primary aquifers situated along the coastline.

Concern about the lack of systematic country-wide groundwater data collection and interpretation led the Directorate of Geohydrology in Department of Water Affairs and Forestry (DWAF) to launch in mid 1990 a programme to compile a series of 21 hydrogeological maps of South Africa at a scale of 1:500 000, each of which has an accompanying explanatory booklet. This was basically an aquifer classification project and was completed in 2005. This was complemented by a series of maps of availability of groundwater, depicting borehole yield probabilities, depth to groundwater-level, groundwater quality / hydrochemical type, mean annual recharge and groundwater contributions to baseflow on a national scale. The main maps basically represent a statistical analysis of information stored in DWAF’s National Groundwater Data Base (Woodford et al, 2006).
In terms of South Africa’s overall water consumption, groundwater contributes only some 15% of the total volume consumed. This percentage belies the fact that over 300 towns and 65% of the population are entirely dependent upon this resource for their water supply. Until the new National Water Act of 1998, groundwater had been defined in law as “private water” and was seen of local importance only. With the democratization of the country in 1994 there was a strong policy shift towards providing basic services, including water and sanitation services, to the whole population as soon as possible. By 2006 the backlog of 15 million unserved people, or about 40% of the population, had been reduced to 4 million and groundwater has played a major role in this regard, serving between 60-90% of rural communities (Braune and Xu, 2009).

4. Preliminary Evaluation of Aquifer Conditions

4.1 General Overview of the Stampriet Kalahari / Karoo Aquifers

The Stampriet Kalahari / Karoo Aquifers cover a total area over the 3 countries of approximately 140,000 km² (71,000 km² within Namibia – Figure 5), with a shared international boundary length in excess of 1,000 km. The system is made up of two confined regional sub-artesian aquifers in the Karoo sediments, overlain by an unconfined aquifer system of Kalahari sediments. Water quality decreases in the flow direction towards south-western Botswana and the north-western Cape in South Africa, resulting in brackish to saline water in these parts.

In Botswana the area is sparsely populated although further development is envisaged and water is required for irrigation, stock watering, game, and smaller villages that are in need of increased water supply.

In Namibia this aquifer system is the main source of water supply for agricultural development as well as for the five urban centres within the region. Isolated rural communities within the NE part of the Basin also receive water from this system. Mining companies are involved in exploration activities within the area and will require groundwater supply in the future. Furthermore, extensive groundwater abstraction for irrigation by commercial farmers occurs in the central western side of the basin.

Within South Africa the water need from this system is mainly required in a large game reserve, the Kgalagadi Transfrontier National Park, for rural domestic use and for stock watering on commercial and communal farms. Fresh water resources are scarce and would require high-level development techniques to investigate potential fresh water in this area. The value of fresh water in this environment can be illustrated by the piped water
transfers into the Molopo basin, south of the Nossob basin, through the Kalahari West and Kalahari East Rural Water Supply schemes. In the area surrounding the Namibian/South African region, only the Kalahari Group aquifers have been developed for utilization, while the underlying Karoo Aquifer Systems have not been studied in detail. Interaction between these two aquifers needs to be investigated in terms of the salinity transfer between the two aquifers.

Recommendations were made to improve the management of the aquifers in terms of sustainable utilization, and on the rehabilitation of inadequately designed boreholes that intersect the artesian aquifers and cause losses due to leakage from the artesian aquifers into the upper Kalahari sediments (JICA, 2002). Further work, to better understand and quantify the degree of losses due to leakage from the artesian aquifers, is required.

For long-term water security, a reliable framework for cooperation and negotiation is necessary between the three states, with assessment of the implications of national and/or joint decisions for the aquifer and mitigating measures taken, based on current available knowledge and data.

Geomorphology
The general topography of the basin is flat, and the elevation of the study area decreases towards the south from 1,350m in the north-west to 850m in the south (Figure 5). Sand dunes, developed in the northern and central part of the study area, are typically trending in a NW-SE direction and are of varying sizes and these continue eastward toward and across the border with Botswana. Two types of drainage are imminent, one being an external drainage of surface streams and the other of an internal drainage of “Pans” probably developed from sinkholes in the distribution area of the Kalahari Beds and these are of varying sizes.

Geology
Within Namibia the Karoo rocks of the Stampriet Kalahari / Karoo Aquifer Systems are largely covered by sediments of the Kalahari Group. Outcrops of the Karoo succession are limited to the western margin of the basin and to a few inliers not covered by the Kalahari near the western margin.

The two sandstone horizons known as the Auob and Nossob Members, within Namibia, are the major aquifers that are mostly confined, within the basin, and are included in the Prince Albert Formation within the Ecca Group of the Karoo Sequence that consists mainly of non-marine sediments deposited in the early Permian Period. Faults and dolerite dykes or sills occur, generally increasing in volume towards the central parts of the basin. The Kalahari Group that overlies the Karroo Sequence within the project area does not have a uniform stratigraphy across the basin. The succession is highly variable and in places, certain gravel or calcrete horizons can be correlated for some distance but they are invariable of limited lateral extent. Figure 6 provides a representative cross-section of a large area within the western part of the basin.

Within Botswana, the major rock formation within the Stampriet Kalahari / Karoo Basin, as shown in Figure 7, (represented by Ncojane and Nossop basins in Botswana) is of the Kalahari/Karoo type. The Karoo Supergroup covers several recognised periods of geological time from the Carboniferous through the Permian, Triassic to the early Jurassic (BNWMPR, 2006, ORASECOM, 2009). They are the major rock and aquifer formations in
Botswana and cover around 70% of the country. From Botswana side, the Ecca sub-group extensively dominates the SAB and a few patches of Dolerite sills are also found in the area. The Ecca group generally contains two major aquifers, the Auob (Otshe in Botswana) aquifer in the upper sequence and the Nossob (Ncojane in Botswana) aquifer at almost the bottom of the Ecca sequence (JICA, 2002). The Auob aquifer contains in general three different sandy layers inter-bedded by coal seams and bituminous mudstones. The two main aquifers, Auob and Nossob, are separated by a thick layer of low permeable sequence of mudstones and siltstones - the Mukorob (Kobe in Botswana) Formation. The Kalahari Group of sediments covers most of the Basin and, as elsewhere reported, pre-Kalahari valleys are of importance for the groundwater occurrence in the Kalahari Beds.

**Figure 6** Geological Cross Section of part of the SKKAs

**Figure 7** - Simplified geology map over Molopo-Nossob basin: Source: (ORASECOM, 2009)
Hydrology and Hydrogeology within the Basin

The Auob and Nossob Rivers are the only major ephemeral streams within the Namibian part of the basin and these originate within Namibia and flow in a south-easterly direction towards the Orange River in South Africa. They only flow for short periods during seasons that have heavier rainfall events.

The Kalahari Aquifer is an extensively-used aquifer within the study area. A pre-Kalahari erosional surface before sedimentation of the Kalahari Beds occurred, known as the “African Surface”, indicates that the Pre-Kalahari Valley was deeply eroded within the south-eastern part of the cross section where the erosion reached the Auob Aquifer as shown in Figure 5. A maximum thickness of the Kalahari Beds of over 250m occurs within this area. Groundwater is generally flowing from the north in a southerly direction and the water quality decreases in the flow direction towards south-western Botswana and the north-western Cape in South Africa, resulting in brackish to saline water in this part. In Botswana, water quality is extremely variable and yields are generally low, consequently Kalahari Group aquifers are not considered a likely target for exploration or exploitation except in very limited cases (BNWMPR, 2006).

The upper confined Auob Aquifer generally has a good water quality, and has been utilized for a long time within Namibia. The withdrawal from the aquifer is generally high in the western part of the basin; where the depth of the aquifer is relatively shallower than in the central parts. Groundwater flow of the Auob Aquifer as a whole is similar to the Kalahari Aquifer i.e. towards south-western Botswana and the north-western Cape in South Africa. The good water quality in the northern part also deteriorates towards the south central part of the project area, but the decrease in quality is at a lower rate than that noticed within the Kalahari Aquifer. In Botswana, the Auob (Otshe) sandstone generally provides sufficient yields (2-3m³/h) for livestock watering in both confined and unconfined conditions. Under semi-confined conditions, it can still yield usable brackish water, but in some cases the water is too saline for any agricultural use (ORASECOM, 2009).

Although the lower Nossob Aquifer has the highest piezometric head of all the aquifers, the total groundwater abstraction from this aquifer is only about 1.3 % of the total abstraction within the Namibian part of the project area. This is mainly due to the thin nature of the aquifer, its excessive depth and the frequent inferior water quality of the aquifer. The general direction of groundwater flow within the Nossob Aquifer is similar to that of the Kalahari and Auob aquifers. The water quality of the Nossob aquifer also becomes more inferior towards the south and the inferior water has a higher aerial extent than that of the Kalahari and Auob Aquifers. In Botswana, this formation is very deep and has very saline water and does not constitute an important aquifer (ORASECOM, 2009).

Recharge

Mean annual rainfall across the basin varies between 120 mm and 240 mm. Rare extreme rainfall events can reach 500 mm. The mean annual potential evaporation exceeds 3,000 mm. According to the C¹⁴ ages in the unconfined Kalahari aquifer, the water is generally old, although younger water occurs in the north-western part of the basin, where recharge has been observed. It is regarded that noticeable groundwater recharge is attributed to heavier rainfall events where recharge into the Kalahari Aquifer is enhanced by the numerous calcritic sinkholes along the NW rim of the basin. Furthermore the Auob Aquifer is recharged indirectly through the Kalahari Aquifer within the NW part of the basin. Recharge is also thought to take place along major fracture lineaments that cut across large parts of
the basin, although this process needs to be better understood. The recharge mechanism on the Botswana/Namibia boundary area is still unknown. Previous studies here, including use of the Chloride Mass Balance Method, have indicated between 0.1 to 1 mm/a recharge (ORASECOM, 2009).

Younger water also occurs along the lower reaches of the Auob and Nossob Rivers, which confirms recharge from the riverbed during flood events into the Kalahari and the Auob aquifers. Recharge events affecting the confined aquifers are only linked to above-average rainfall episodes within the basin. This is clearly evident from the piezometric response at relevant monitoring localities intercepting the confined layers within parts of the basin. Generally the water of the Nossob Aquifer is very old with very little recharge occurring.

**Water quality**

Groundwater quality deteriorates in a south-southeasterly direction, because the Kalahari in the central parts of the basin consists mainly of fine sand, silt and clayey deposits which have accumulated mineral salts due to low rainfall and runoff as well as high evaporation. This area mostly coincides with the Pre-Kalahari Valley and represents the major discharge area of the basin. The confining layer of the Auob Aquifer has also been largely eroded in the south-eastern parts of the pre-Kalahari River, resulting in saline groundwater. In fact, the southern area of the system is referred to as the “Salt Block” because of the brackish to saline water in these parts. Within Namibia a maximum concentration of TDS of 14,874 mg/l was recorded and within Botswana over 20 000 mg/l.

For the larger Molopo-Nossob basin, ORASECOM (2009) reports that the groundwater is unsuitable for human consumption in 74%, 28% and 41% of the basin respectively in Botswana, Namibia and South Africa and unsuitable for livestock in 52%, 1% and 5% of the areas respectively.

Nitrates present in large areas of the aquifer system also limit groundwater use. Most of these nitrates are of natural origin. They extend to the artesian part of the aquifers via the overlying Kalahari Beds. The nitrate concentration in groundwater can vary over a very wide range depending on the aquifer and its recharge characteristics. During extreme rainfall events, large areas are flooded and the groundwater recharge processes are modified, causing leaching of salts, including nitrates, which collected in the unsaturated zone over many years. This may affect the groundwater quality to such an extent that it becomes toxic, even to livestock (Tredoux, 2009).

**Groundwater Potential Evaluation**

Within Namibia recharge volumes into the system was calculated at 0.105 billion m$^3$/year within the normal rainfall seasons and this is equivalent to approximately 0.4% of the total rainfall within the catchment area. Recharge during the 1999-2000 rainy season, which has a probability of one in 50 years, was considerably higher at 1.3 billion m$^3$/year, that is approximately 15 times higher than an ordinary year.

Based on the current recorded abstraction records, the total annual abstraction from the system exceeds 18 Mm$^3$/annum. However natural and human-induced leakage and losses from the system, including discharge out of the system, needs to be better quantified in order to determine the sustainable amount of water available for use.

Furthermore it is imperative to obtain a better understanding on the volume of losses due to natural leakage from the confined aquifers that is generally tectonically related by way of larger fracturing within the basin.
In general, the study area is dominated by intergranular type of aquifers which have low to medium yields (Figure 8) ranging between 1.8 m$^3$/h and 7.2 m$^3$/h in Botswana compared to 3 m$^3$/h to more than 15 m$^3$/h in Namibia. In both countries, higher yields are attributed to the Ecca formation. More information is still needed in Botswana to assess the extent to which the Ecca formation in Botswana, Namibia and South Africa are related. A regional hydrogeological study will also shed light on the similarity (or otherwise) of the vertical profile of the Ecca group and any other dominant aquifer group. This is because on the western side of Ncojane (across the border into Namibia) the confined and artesian Stampriet basin in Namibia supplies good quality groundwater (BNWMPR, 2006). It is conjectured that this basin may straddle the Botswana border (at least at the edge) into the Ncojane and Ukwiv village areas on the basis of groundwater flow, which flows from the Stampriet in Namibia to Ncojane in Botswana. Evidence from boreholes in the Ncojane village (water strikes are generally confined below coal and dolerite layers) show yields up to 50 m$^3$/hr and have been assessed as potentially being much greater (up to 100 m$^3$/hr) in the DWA 2001 village supply project.

Figure 8 - Groundwater potential map for the three countries (Source: ORASECOM, 2009). The area in circle includes the SAB

Environmental Considerations

One of the significant environmental resources in the study area is the Kalahari Transfrontier Park, which is shared by the three countries. A co-ordinated and integrated management of the SAB by the participating countries may improve water situation in the park, more so because there are limited surface water resources within and around the park. There is need for the sustainable use of these groundwater resources, both from a water services as well as an environmental services point of view.

Bush encroachment is noticeable within parts of the major riverbeds. Within the project area the alien Prosopis species is responsible for destroying the habitat of the natural vegetation. Evapo-transpiration is very high in areas with high levels of bush encroachment. The water consumption by these plants as a result of bush encroachment over large areas is high and impedes recharge of the aquifer and the magnitude of this is unknown and requires further investigation.
Socio-economic Considerations

Demography - During early 2000 the population within the Namibian portion of the Basin was as follows:

<table>
<thead>
<tr>
<th>Type</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Village centres</td>
<td>6,186</td>
</tr>
<tr>
<td>Commercial farms</td>
<td>16,780</td>
</tr>
<tr>
<td>Communal land</td>
<td>12,130</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>35,096</strong></td>
</tr>
</tbody>
</table>

Taking into account the annual growth rate, the current population within the project area is in the order of 42,000 people.

The SAB in Botswana falls under Kgalagadi and Ghanzi districts. Based on the 2011 population census in Botswana, the population of Kgalagadi and Ghanzi were 50,492 and 43,095, respectively (Central Statistics Office - CSO, 2011). However, the closest major villages and their populations are Ncojane (1,958), Hukuntsi (4,654), Tsabong (8,939), and Bokspits (507) with a total of around 16,000 (i.e. less than 1% of the total population).

In the last five years, various policies that seek to promote economic diversification (to reduce over reliance from diamonds), poverty eradication and citizen empowerment have been passionately advanced by the government of Botswana. In some areas, this has lead to significant growth in arable and pastoral farming (including participation by young farmers, who at times are given grants and loans to start or grow their farming businesses). It will be important to assess if these policies have increased groundwater demand in the area, and how this can be managed to avoid over-utilization of groundwater resources in the study area.

Water Utilisation - During the JICA study of the SAB that was completed in 2002, the water usage within the Namibian side of the project area was 15.6 Mm³ per annum. Based on the sectoral breakdown, usage was as follows and most of these figures remain to be updated:

- **Irrigation** – accounted for 44% of the water consumption or 6.9 Mm³/ annum. Commercial irrigation for diverse crop farming within parts of the area has been practiced for a long time, and is largely situated along the Auob river, where in excess of 70% of the irrigation is concentrated and more specifically within the surroundings of the Stampriet area. According to current irrigation records the present abstraction rate has increased to 9.1 Mm³/ annum.

- **Domestic watering** amounts to 15% of the water consumption or 2.4 Mm³/ annum.

- **The 5 urban centers** that are supplied with water by the bulk water supplier, NamWater, amounts to 4% of the water consumption, or 0.6 Mm³/ annum

- **Stock watering** amounted to 37% of the water consumption or 5.69 Mm³/ annum. Within both the commercial and communal areas stock farming is the major source of livelihood.

In Botswana, the use of water in the area is based on groundwater or temporary surface water ponds such as pans, filled after rainy seasons. For sustainable water supply, boreholes and wells are used and all rural and major villages have their supply based on groundwater. Water is used mainly for livestock watering, human consumption and wildlife with a total water requirement of about 6.5 Mm³/a. Cattle watering accounts for more than 65% of these water requirements.

The comparative water use in the South African part of the basin is 2.0 Mm³.
**Water Resources Management** – Within the project area in Namibia the drilling of boreholes and the permitted irrigation is controlled through a licensing system. According to the departmental records, the permitted total irrigation area currently covers 550 ha, and the current water allocation stands at 9 057 040 Mm\(^3\)/annum. User participation has been institutionalized in Namibia through Basin Management Committees and within the framework of IWRM, these licenses are reviewed through the Basin Management Committees in collaboration with the users through a user group committee prior the allocation by the Department. In order to manage the system effectively in terms of the Water Resources Management Act, the technical and administrative capacity of the Department of Water Affairs and Forestry will need to be strengthened.

While groundwater in South Africa is recognised as a ‘significant water resource’ to which all sections of the Act apply, no provision has been made so far in the National Water Act, 1998 or in regulations for the unique characteristics of groundwater, e.g. the need for its pro-active protection and for local institutions for its management and conservation. A first systematic assessment of the provisions for groundwater governance in South Africa was undertaken in 2010 in a case study as part of a world-wide Economic and Sector Analysis by the World Bank (World Bank, 2010). The indicator-based study concluded that groundwater governance provisions need urgent strengthening in terms of groundwater resources regulation and institutional capacity at both national and local level. A National Groundwater Strategy has recently been completed that has come to very much the same conclusions and provides recommendations for a more focused attention to groundwater resources governance.

### 4.2 Resource Status

From the groundwater monitoring network that has been extended to cover a reasonable area within the Namibian part of the basin it is clear the water levels only show significant amounts of recovery after exceptional rainfall events. Water level records since 1986 showed a constant average decline of approximately 5 cm/year and in some parts of the basin, artesian pressure has decreased by up to 10 m. This pattern was however altered after the heavy rains from 1999 to 2000 that was significantly above the average, and significant recharge occurred.

Due to limited data availability in Botswana, it is difficult to provide estimates of the total groundwater availability in the area. However, a number of studies have been undertaken to try and assess aquifers in different parts of the country. These include, among others Groundwater Recharge Estimation Study (GRES I and II), a research project implemented by the University of Botswana, Department of Geological Surveys in association with the ITC of the Netherlands. This was set up to measure recharge rates in Botswana between 1987 and 1997. Another study is the ORASECOM’s groundwater review of the Molopo-Nossob basin project conducted in 2009. In addition, the Department of Water Affairs (DWA) routinely carries out groundwater exploration and resource quantification (DWA, 2008). The TBA project can use results and lessons learnt from these past projects to undertake focused and detailed regional aquifer monitoring and assessment within the riparian states.

### 4.3 Key Issues – resource system

For its sustainable and shared utilization, the resource system needs to be better understood, in particular in terms of its recharge mechanisms, natural leakage that is occurring within the basin through structural causes and the impact of abstraction on wetlands and ecosystems.
Losses due to leakage from inadequately designed boreholes throughout the basin may be enormous and need to be addressed through appropriate technology and effective institutions.

Besides the water quality generally decreasing in a southerly direction, nitrates of natural origin are present in large areas of the basin, and that also limits the groundwater use. Local quality degradation due to anthropogenic nitrate pollution also imposes problems in some areas, largely due to stock watering localities within the proximity of the boreholes.

Possible mining of the reported coal deposits within and surrounding the upper artesian aquifer will impact on the integrity of the water quality. Leakage out of the system from possible mining will also impose a serious challenge that needs to be addressed.

4.4 Key Issues – socio-economic system

In Namibia, the extension of the national electricity supply network to this area has increased the economic viability of irrigation farming and will have a positive impact on job creation and towards promoting food security. Further expansion will be limited only by the availability of water and thus the sustainable potential of the groundwater resource needs to be established as a matter of priority. Furthermore, efficient irrigation practices and good management will have to be promoted.

Livestock raising makes up the most important part of people’s livelihood in all three countries, but in many cases the quality of the groundwater is such that it affects the health of the animals and the viability of stock farming. Finding, developing, and protecting utilizable groundwater sources in this complex aquifer environment will be of strategic importance. Existing policies should be harmonized and adjusted to suit local conditions based on new and improved information on groundwater availability and potential in the study area.

Mining potable water resource for purposes other than water supply is not considered justifiable within such an arid and often drought-stricken environment. By mining groundwater (particularly for irrigation projects), communities may find themselves forced to move when the resource is depleted. This is viewed as most unfavourable in a social context and almost certainly disastrous in economic terms.

The economically important Kalahari Transfrontier Park is largely dependent on groundwater resources. The role of groundwater for the maintenance of arid zone ecosystems needs to be much better understood, so that the economically important wildlife resources in all three countries can be secured.

Conflicts between Namibia and Botswana have already occurred over available surface water in the basin. Future groundwater-related conflicts could arise due to growing water demand on all sides as a result of population growth and climate changes. Joint management of shared resources based on a holistic understanding of the surface water / groundwater system will become essential.

4.5 Relevant information

The SADC Sub-Committee for Hydrogeology, so far has established a full situation analysis in the 14 SADC Countries regarding groundwater management setting and standards and procedures for Groundwater Development, and prepared a ‘Regional Code of Good Practice for Groundwater Development’ (Wellfield Consulting Services Pty Ltd & British Geological Survey, 2003). This code of good practice initiates harmonisation and improvement of
practices, serves as guideline and is on the SADC Agenda for implementation, through the SADC project on Standardisation (SADCSTAN). Some further thoughts on developing a transboundary basin information system were expressed in ORASECOM (2009).

A major step forward towards harmonization of hydrogeological information in the region, has been the production of a web-based SADC hydrogeological map and atlas at a scale of 1:2,500,000. The map comprises the following layers:

- Roads and major towns
- International boundaries
- Digital elevation model
- Rainfall
- Recharge
- Surface water features, including perennial and non-perennial rivers
- International river basins
- Lithology and geological structures
- Aquifer types and associated groundwater productivity
- Transboundary aquifers
- Water quality

To support the hydrogeological mapping, the SADC Hydrogeological Mapping Borehole Database, held at the Geological Survey of Botswana, was compiled.

Botswana, Namibia and South Africa were active participants in the SADC mapping project. Each country has its own hydrogeological database and has already mapped its groundwater resources. Various forms of groundwater modeling have already been carried out by the respective countries on parts of the Kalahari-Karoo aquifer system. A conceptual model for the combined aquifer has already been developed and has simulated the groundwater flux across political boundaries. The study concluded that sharing of data and multilateral cooperation is essential for the management of the aquifer (Peck, 2009).

The task of data collation and sharing for the study area can be illustrated with the case of Botswana. It requires collation of information stored in different government departments and ministries which previously were involved in water resources management, such as Department of Geological Survey, Ministry of Local Government, Department of Mines and Department of Meteorological Survey. This information will augment those routinely collected by the Department of Water Affairs. From there, data gaps can be identified and where possible the project should support additional data gathering. The entire process should take into account what else is available in the other riparian countries; explore possibility of data sharing, joint studies, management, utilisation, monitoring and protection of transboundary aquifers for sustainable groundwater resource management which will improve people’s livelihood.

4.6 Water Sector Stakeholders

A brief overview is provided of the goals and strategies of the water sector in each of the three countries, followed by a breakdown, in Appendix 1, of the key stakeholders and their roles in the respective countries.
4.6.1 Water Sector in Botswana

Following the review of national water master plan in 2006, Botswana water sector is in a transition mode (known as the Water Sector Reform Process) as a result of implementing the recommendations made from the review. In order to improve accountability and efficiency in the water sector, new institutions are created and the roles of existing institutions have changed. The new institutional framework under the reform is as follows (Centre for Applied Research - CAR, 2013):

**Department of Water Affairs (DWA)**
The DWA will continue to be wholly financed by central government and has the overall responsibility to assess, plan, develop and maintain water resources for domestic, agricultural, commercial, industrial and other uses in the whole country. In order to effectively implement these leadership roles, DWA will assist and advise in the formulation of water resources development and management policies and legislation. DWA will undergo a significant restructuring under the reform in order to fully implement its roles and responsibilities. Some of the sections of Department of Geological Survey (e.g. hydrogeology unit) will relocate to DWA.

**Water Utilities Corporation (WUC)**
WUC will be responsible for the delivery of fresh water and wastewater treatment services country wide. Thus far, WUC has taken over supply to 373 villages (out of the planned 540 villages). The largest remaining area is Maun and surrounding areas. With regards to wastewater management services, all the entities in the country have been completely taken over except for the Maun area. WUC seems on track in meeting the take-over target of all 540 villages by 2014.

**The Water and Energy Regulator**
This entity will be primarily charged with ensuring financial sustainability across the water sector, reducing wastage by facilitating the streamlining of operations and determining revenue requirements to inform regular tariff adjustments (Draft National Water Policy, 2011). The regulator will also oversee compliance of service standards to ensure efficiency and protect consumer rights. The regulator will, however, regulate more than one sector, e.g. water, energy, and telecommunications. This body should become financially sustainable in fully assuming its roles and responsibilities.

**Water Resources Board (WRB)**
As an autonomous body supported by Ministry of Minerals, Energy and Water Resources (MMEWR), the WRB will oversee and allocate Botswana’s scarce water resources. It will also monitor these resources and develop water related policies. The Council with ensure independence and equity in the sustainable allocation of water resources. The WRB will replace the Water Apportionment Board (WAB) and will have members from the following entities: MMEWR, Ministry of Environment, Wildlife and Tourism, Ministry of Agriculture, large water users, WUC, research and academia as well as civil society. It is envisaged that the Council will be wholly financed from the central government coffers. However, as time goes on, the revenues collected from licensing and water abstraction fees could support the operations of the Council.
4.6.2 Water Sector in Namibia

*Fundamental Principles to Promote Sound Water Resources Management*

Within Namibia the main objective of the Water Resources Management Act is to ensure that the water resources of Namibia are managed, developed, used, conserved and protected in a manner consistent with and conducive to the following fundamental principles:

- **To achieve equitable access to water**, i.e. equity of access to water services, to the use of water resources, and to the benefits from the use of water resources;
- **promotion of the sustainable development of water resources** based on an integrated water resources management plan which incorporates social, technical, economic, and environmental issues;
- **To achieve efficient and effective water use** for optimum social and economic benefit recognition and to account for the economic value of water in the allocation of water.

As equitable access for all people to safe drinking water is an essential basic human right to support a healthy productive life, other important proposals to achieve the National Water Policy’s objective include:

- That the State, in its capacity as owner of the water resources of Namibia by virtue of Article 100 of the Constitution of the Republic of Namibia, has the responsibility to ensure that water resources are managed and used to the benefit of all people;
- cognisance of the regional diversity in water resources development and the decentralisation of responsibilities to the lowest level of Government where adequate and appropriate competency exists to manage water resources effectively;
- Promote community based social development taking the role of women into special account;
- cognisance of Namibia’s international rights and obligations in the utilization of internationally shared water resources.

*Basin Management Approach and General Water Resources Strategy*

The country has been sub-divided into 15 basin management areas through which stakeholder representation can consult with the Department of Water Affairs and Forestry that is the guardian of the country’s water resources, as well as with other service providers such as NamWater, that is the major national bulk water utility, and with Regional and Local authorities (Figure 9). This includes matters relating to the development, management, protection and enhancement of water resources within the basin. The formation of Basin Management Committees is furtherance of the Government’s objective in achieving integrated management of the water resources.

In order to improve access to safe water for communities in rural, communal areas, the establishment of Directorate that is responsible for Rural Water Supply within the Department of Water Affairs and Forestry, known as the Directorate for Water Supply and Sanitation.
Coordination, laid the foundation for the successful implementation of a dynamic strategy, known as Community Based Management (CBM). This strategy involves extensive user participation in water supply and management in the form of Water Point Associations in consultation with Basin Management Committees.

The general acceptance of the Water Supply and Sanitation Policy by the stakeholders represents only a foundation from which to work. The productivity and growth of the Water Supply and Sanitation sector will, to a large extent, depend on political will at all levels, the provision of adequate funding, the continuous development of adequate human resources, community participation and the dedicated implementation of the identified strategies by all role players to achieve the objectives of the policy.

The Ministry of Agriculture, Water and Forestry remains responsible for the overall management and regulation of the water cycle and water resources in the country with the prime objective of ensuring that they will be properly investigated and used on a sustainable basis to cater for the needs of people and to sustain their environment.

Local Authorities and Regional Councils are responsible for implementation of water supply and sanitation in the urbanised areas and rural settlements (proclaimed and un-proclaimed) where demand is continually increasing and a growing backlog exists.

The Division for Rural Services of the Department of Water Affairs and Forestry, which includes regional, communal rural water supply (RWS), within the Regional Councils, will continue to implement support to communal rural water supply while fully integrating rural sanitation within its functions.

**Figure 9 - Basin Management Areas within Namibia**

**Water Sector Stakeholders**

Certain functions relate to statutory and others to general responsibilities such as water quality and pollution control and sanitation. These responsibilities include:

- Overall water resource inventory, monitoring, control and management issues are to remain the responsibility of the Ministry of Agriculture, Water and Forestry.
- For supply of water in bulk which cannot be handled by an individual Local Authority, the Local Authority may approach NamWater or any other willing partner to construct the necessary infrastructure provided that such agreement is approved by the responsible Minister.
- Public health considerations and user health education campaigns are the responsibility of the Ministry of Health and Social Services with the Local Authorities and Regional Councils taking part in or discharging these functions in their areas.
Supply of water and provision of sanitation services to the rural communities is to be coordinated by the Directorate of Water Supply and Sanitation Coordination within the Ministry of Agriculture, Water and Forestry.

The Ministry of Lands and Resettlement is responsible for the establishment of water supply and sanitation on resettlement farms, coordinated by the Directorate of Water Supply and Sanitation Coordination in the Ministry of Agriculture, Water and Forestry.

Planning, development and operation of National irrigation schemes are the responsibility of the Department of Agriculture in the Ministry of Agriculture, Water and Forestry, while farmers and other communities on private land take full responsibility for their own water supply and provision of sanitation. The Directorate of Resource Management may provide information and exercise control, inspection or monitoring functions with regard to the water usage that has been permitted through a water usage licensing procedure.

For independent government centres including rural schools, clinics and border posts, the relevant Ministries must provide water supply and sanitation facilities and take full responsibility, including budgetary provision, for these facilities. The Department of Works may be contracted by the relevant Ministry to oversee implementation of development.

Other important actors, Government Ministries / Organisations / Stakeholders are included in the table below that provides a summary of the important Water Sector Stakeholders within the country.

### 4.6.3 Water Sector in South Africa

**Overall Development Goals**

Three fundamental objectives for managing South Africa’s water resources, which are firmly grounded in the provisions of the Bill of Rights of the Constitution of South Africa, 1996 (No. 108 of 1996) arise from the Principles. These are the following:

- **To achieve equitable access to water**, that is, equity of access to water services, to the use of water resources, and to the benefits from the use of water resources.

- **To achieve sustainable use of water** by making progressive adjustments to water use with the objective of striking a balance between water availability and legitimate water requirements, and by implementing measures to protect water resources.

- **To achieve efficient and effective water use** for optimum social and economic benefit.

“Of all natural resources, water permeates perhaps most deeply into all aspects of our life. It is as essential as the air we breathe for our survival; its presence determines the nature of the natural environment in which we live; the majority of our economic activities depend on it. The achievement of South Africa’s development vision will thus only be possible if water resources are managed in a way which is sensitive to and supportive of the many demands we place on them” (White Paper on a National Water Policy for South Africa 1997).

Important proposals to facilitate achievement of the National Water Policy’s objectives include the following:

- Water will be regarded as an indivisible national asset. National government will act as the custodian of the nation’s water resources and its powers in this regard will be exercised as a public trust.
Water required to meet basic human needs and to maintain environmental sustainability will be guaranteed as a right, whilst water use for all other purposes will be subject to a system of administrative authorisations.

The responsibility and authority for water resource management will be progressively decentralised by the establishment of suitable regional and local institutions. These will have appropriate community, racial and gender representation to enable all interested persons to participate. A map of the original 19 Water Management Areas, for implementation purposes grouped into nine areas, is shown below (Figure 10).

**Figure 10 - Map of the revised nine Water Management Areas in South Africa**

National Water Resource Strategy

The NWRS-2 sets out the strategic direction for water resources management in the country over the next 20 years, with a particular focus on priorities and objectives for the period 2013 – 2017. It provides the framework for the protection, use, development, conservation, management and control of water resources for South Africa, as well as the framework within which water must be managed at catchment level, in defined water management areas. It is binding on all authorities and institutions exercising powers or performing duties under the National Water Act (Act 36 of 1998).

The NWRS-2 is centred around a recognition of water as a basic human need, and a recognition of its critical role to ensure equitable socio-economic development. The principle of equity means that special attention must be given to the needs of those that were historically denied access to water or to the economic benefits of water. Equity implies a concept of fairness, which allows for different practices in the management of water in response to different social, economic and environmental needs. In order to bring equity to a practical level it is important to distinguish between equity in access to water services, equity in access to water resources and a thirdly, equity in access to benefits from water resource use through economic, social and environmental development and management.

Equally important is the participation of people in water management. In particular, the participation of the poor is critical in eliminating poverty and ensuring the political legitimacy of policies and strategies. Participation has evolved over the last eighteen years from a passive model to a more action-oriented concept. Top-down consultation,
has been replaced by citizen participation. This is a critical approach underpinning and supported in the NWRS-2.

However, for water to play an optimal role in poverty eradication, growth and development, and building a just and equitable society, water resources planning must be integrated into national, provincial and local planning, and must be addressed in all growth and development strategies.

The National Water Resources Strategy encompasses the following critical thrusts:

- Building an efficient water administration by fostering innovation and knowledge management, investing in people’s capabilities, cultivating a more water educated and literate society, as well as increasing economic growth and social development;
- Promoting an equitable water sector by eliminating unequal access to water and reducing imbalances within and among groups as well as regions, perpetuated largely by pervasive administrative inefficiencies;
- Sustaining high water infrastructure investment and development by strengthening the sources of growth, the financial, corporate and water institutions as well as investing in pro-poor local-level infrastructure;
- Enhancing Indigenous Knowledge Systems to meet the challenges of globalization, focusing on the role of women and the youth. The Water Research Commission should be required to conduct research on indigenous knowledge systems, focusing on the role of women and youth;
- Developing a knowledge-based water sector as a strategic move to raise the value added of all water initiatives and optimizing the brain power of the nation. In this regard, also, the Water Research Commission has a special role to play;
- Strengthening human resource development to produce an efficient, effective and knowledgeable workforce; and pursuing water security and environmentally sustainable development to reinforce long-term growth;
- Pursuing sound infrastructure management, and ensuring prudent investment policies as well as enhancing efforts to develop a knowledge-based water economy;
- Strengthening and streamlining redress strategies and mechanisms to ensure balanced participation among and within cultural and income groups as well as enhancing performance of water institutions through improvement in user’s knowledge, skills and expertise as well as upgrading innovation, science and technology;
- Increasing efficiency and economic growth through accelerating the shift of the work-force towards more efficient performance processes and high-value added activities. However, this should not be done at the expense of jobs; and the growth must have a job creation as its basis and rationale;
- Expanding the usage of Information and Communication Technology (ICT) and across and within the water sector to accelerate the growth process;
- Strengthening the human resource base to ensure the availability of person power with higher levels of knowledge, technical and analytical skills;
- Adopting an integrated approach in addressing water quality and environmental issues to attain sustainable development;
- Enhancing further the quality of life through improving accessibility to quality water as well as developing the aesthetic and spiritual dimensions of water; and
• Intensifying efforts to nurture and inculcate positive values and attributes among users through the education system, social and religious organizations and the media (Department of Water Affairs, 2012).

5 References

5.1 Botswana


5.2 Namibia


Geotechnical Consulting Services (2008): - Groundwater Review of the Molopo-Nossob Basin for Rural Communities including Assessment of National Databases at the Sub-basin Level for Possible Future Integration – ORASECOM


5.3 South Africa


Wiegmans F (2006). Groundwater situation assessment in Water resources strategy for the Kgalagadi District. Kgalagadi District Municipality,


5.4 Southern Africa


## Appendix 1 – Comparative Summary of Water Sector Stakeholders within the 3 Countries

<table>
<thead>
<tr>
<th>Category</th>
<th>Specific Key Stakeholders</th>
<th>Role</th>
<th>Specific Instruments / Processes</th>
<th>Category</th>
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<th>Category</th>
<th>Specific Key Stakeholders</th>
<th>Role</th>
<th>Specific Instruments / Processes</th>
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</thead>
<tbody>
<tr>
<td>Core Public Agencies (Sector ministries, implementing agencies, regional directorates, etc)</td>
<td>Catchment management agencies (CMAs)</td>
<td>Core Public Agencies (Sector ministries, implementing agencies, regional directorates, etc)</td>
<td>Basin Management Committees, Water Point Committees</td>
<td>Core Public Agencies (Sector ministries, implementing agencies, regional directorates, etc)</td>
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<td><strong>Catchment Committees</strong></td>
<td>Responsible for decentralised implementation of measures that affect water, guided by a catchment management strategy for each catchment. Substructure of a CMA</td>
<td>Established in terms of the National Water Act 1998 in 19 Water Management Areas, combined into nine areas for implementation purposes.</td>
<td>Management of all activities aimed at enhanced functioning of a water basin. (Public Private Partnership)</td>
<td>In terms of the Water Resources Management Act 2011</td>
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<td><strong>National government departments</strong> (Agriculture, Mining, Energy, Forestry, Environment, Human Settlement, Rural Development, Land, etc)</td>
<td>These are mandated to implement functions that affect or are affected by the availability of water.</td>
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<td><strong>National government departments</strong> (Agriculture, Environment and Tourism, Lands and Resettlement, Works and Transport, Mines and Energy, Fisheries and Marine Resources, Health and Social Services, Regional, Local Government and Housing, Defence)</td>
<td>Are mandated to implement functions that affect or are affected by the availability of water.</td>
<td>Environmental Management Act and other relevant Acts</td>
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<td>Ministry of Agriculture (dryland crops, livestock &amp; irrigation) National Farmers Association</td>
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<tr>
<td>Core Public Agencies (Sector ministries, implementing agencies, regional directorates, etc)</td>
<td>Disaster Management Inter-Governmental Committee on Disaster Management.</td>
<td>Very important, because of the endemic nature of occurrences of floods, droughts, and environmental disasters.</td>
<td>National Disaster Management Act, 2002</td>
<td>Core Public Agencies (Sector ministries, implementing agencies, regional directorates, etc)</td>
<td>Disaster Management Under the Office of the Prime Minister</td>
<td>The Department of Water Affairs will contribute towards dealing with issues like floods, droughts, and environmental disasters.</td>
<td>Core Public Agencies (Sector ministries, implementing agencies, regional directorates, etc)</td>
<td>Department of Tourism, HATAB, Botswana Tourism Organisation (BTO), Botswana Wildlife Management Association, CBNRM forum &amp; BOCOBONET, Tour operators</td>
<td>Water for tourism, wildlife, CBNRM</td>
<td>Tourism</td>
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<tr>
<td>Regional Offices of the Department of Water and Environment Affairs</td>
<td>An office in each province nine in total; Some functions will be carried over into the Catchment Management Agencies, once these are functional.</td>
<td>Regional Offices of the Department of Water and Forestry</td>
<td>A regional water and sanitation office has been established within each region</td>
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<td>Dept. of Mines, Botswana Confederation of Commerce, Industry and Manpower (BOCCIM), Mining companies</td>
<td>Water for private companies (small, medium and large scales)</td>
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<td>Provincial government departments (agriculture, health, environment, etc)</td>
<td>Engage in functions that affect water use</td>
<td>Provincial government departments (Regional, Local Government and Housing, etc)</td>
<td>Engage in functions that affect water use</td>
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<td></td>
<td>BOCCIM, Water appliances supply sector</td>
<td>Private companies proving water tanks and reservoirs</td>
<td>Industry &amp; service sector</td>
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<tr>
<td>Public/quasi-government institutions (e.g. ESKOM)</td>
<td>These are responsible for business activities that affect and require water resources.</td>
<td>Parastate Companies (NamPower, Namibia Wildlife Resorts, etc)</td>
<td>Are responsible for business activities that affect and require water resources.</td>
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<td>Dep. of Environmental Affairs, Dep. of Waste, Management and Pollution Control, Dep. of Wildlife &amp; National Parks, Parliamentary Committee, Dep of Meteorological Services, SADC, RBOs</td>
<td>Mainly for the protection of environment where water is sourced</td>
<td>Environmental water use</td>
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<tr>
<td><strong>Core Public Agencies</strong> (Sector ministries, implementing agencies, regional directorates, etc)</td>
<td><strong>Local Government</strong></td>
<td><strong>Core Public Agencies</strong> (Sector ministries, implementing agencies, regional directorates, etc)</td>
<td><strong>Local Authorities</strong></td>
<td><strong>Core Public Agencies</strong> (Sector ministries, implementing agencies, regional directorates, etc)</td>
<td><strong>Local government</strong> Parastatals (BHC, BPC, BTC, WUC),</td>
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| **Local participatory institutions**  
Water Committees  
Water Point committees | Local Government are the water services authorities and are responsible for providing potable water services to domestic consumers | These type of grassroots structures have lost their role in South Africa since the advent of elected local government | Local participatory institutions  
Water Committees  
Water Point committees | Bodies that represent water users at different levels |  |
| **Service Providers**  
(Public companies or private companies entrusted with service delivery) | Water boards, eg Rand Water  
Joburg Water  
KOBWA  
Mvula Trust | Service Providers (entrusted with water service delivery) | NamWater | Parastatal Company responsible for Bulk Water Supply on a National Level | In terms of NamWater Act, 1997 |
| **Oversight Organisations**  
(For monitoring purposes) | Parliamentary Portfolio Committee (on Water and Environment) | Oversight Organisations (Financial and legal monitoring; complaint handling etc) | Ministry of Finance | Responsible for Financial Control of State Spending | For monitoring purposes  
Will replace WAB  
New players on the field | |
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<td>National Treasury</td>
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<td>Public Protector</td>
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<tr>
<td>Non-state Actors (Citizens, voters, user associations, consumers, economic operators, media)</td>
<td>Water User Associations User Associations (umbrella) Association of WUAs, AgriSA, Water user associations are co-operative associations of individual water users at a localized level, who wish to undertake water related activities for their mutual benefit. These play a role in advocacy, lobbying and implementation of water sector programmes</td>
<td>Water User Associations in terms of NWA, 1998</td>
<td>Non-state Actors (Citizens, voters, user associations, consumers, economic operators, media)</td>
<td>User Associations Agricultural Associations Representative bodies for interaction lobbying of water needs, etc.</td>
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<td>Non-state Actors</td>
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<td>Consumers and civil society</td>
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<td>Domestic water consumption</td>
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<td>Domestic consumers</td>
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<tr>
<td>Non-state Actors (Citizens, voters, user associations, consumers, economic operators, media)</td>
<td>Industry Represented through organised business (Chamber of Mines, Chamber of Business / Business Unity South Africa etc)</td>
<td>Non-state Actors (Citizens, voters, user associations, consumers, economic operators, media)</td>
<td>Industry and Mining represented through organised business (Chamber of Mines, Chamber of Commerce)</td>
<td>Non-state Actors (Citizens, voters, user associations, consumers, economic operators, media)</td>
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<td>Non-state Actors</td>
<td>Players such as mining companies carry business that affects water use</td>
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<td>Non-state Actors</td>
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<td>NGOs</td>
<td>Mvula Trust, Association for Water &amp; Rural Development (AWARD) etc</td>
<td>NGOs</td>
<td>NGOs such as the Desert Research Foundation, Millennium Challenge Account, etc.</td>
<td>NGOs</td>
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<td>NGOs</td>
<td>SA Water Caucus</td>
<td>NGOs</td>
<td>NGOs – involved with water needs of certain communities</td>
<td>NGOs</td>
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<td>NGOs</td>
<td>NGOs have largely lost their role in South Africa since the coming of elected local government. The SA Water Caucus (SAWC) is a network of more than 20 community-based organisation, non-government organisations and trade-unions active in promoting the wise, equitable and just use, protection and provision of water.</td>
<td>NGOs</td>
<td>NGOs – involved with water needs of certain communities</td>
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<td>NGOs – involved with water needs of certain communities</td>
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<td>Church organizations</td>
<td>eg. Tateni Home Care Services; Bethesda Outreach Ministries</td>
<td>Church organizations</td>
<td>Community care and empowerment activities</td>
<td>Church organizations</td>
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<td>Non-state Actors (Knowledge)</td>
<td>Institutions of Higher Learning and Research such as universities, Water Research Commission and Council for Scientific and Industrial Research, Department of Science &amp; Technology (DST)</td>
<td>Conduct and facilitate learning and research on water resources</td>
<td>Non-state Actors (Knowledge)</td>
<td>Institutions of Higher Learning and Research such as University of Namibia, Polytech</td>
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<td>Non-state Actors (Knowledge)</td>
<td>Water Research Commission</td>
<td>The WRC is the co-ordinator of water-related research and development in South Africa. Through its funding and networking activities it encourages the development of water-related knowledge and facilitates its dissemination and application.</td>
<td>Media</td>
<td>Water Research Act, 1970</td>
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<tr>
<td>Non-state Actors (Knowledge)</td>
<td>Water Sector Professional Bodies</td>
<td>Non-state Actors (Knowledge)</td>
<td>Schools</td>
<td>awareness creation; environmental monitoring</td>
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<td>Water Institute of South Africa (WISA); Groundwater Division of the Geological Society of South Africa; Borehole Water Association of South Africa; South African National Committee of the IAHS</td>
<td>Actively promote peer learning and knowledge management for water professionals WISA is a Southern African voluntary non-profit association comprising water sector professionals, interested parties, companies, government departments, educational &amp; research institutions, local authorities and associated organisations.</td>
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<td>Networks</td>
<td>WaterNet; CapNet; Win-SA; NEPAD Southern Africa Water Centres of Excellence</td>
<td>Environmental Education Organisations eg Wildlife Society of South Africa</td>
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<td>Media</td>
<td>Watchdog role; awareness creation</td>
<td>Schools</td>
<td>Awareness creation; environmental monitoring</td>
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<td>Environmental Education</td>
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<tr>
<td>Transboundary and Regional Organisations</td>
<td>Regional Water Management Organizations</td>
<td>Common to all three countries</td>
<td>Transboundary and Regional Organisations</td>
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<tr>
<td>African Ministers’ Council on Water (AMCOW)</td>
<td>AMCOW is a unique, continent-wide organisation</td>
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<td>SADC Treaty, 1992</td>
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<td>The basis for cooperation among member states in SADC was established in 1992 with the signing of the SADC Treaty. Cooperation in various sectors was initiated by way of protocols. Highest governing body: Council of Ministers. Execution through the SADC Secretariat, including a Water Division.</td>
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<td>Revised Protocol on Shared Water Courses, 2003</td>
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<tr>
<td>Regional Development Organisations</td>
<td>Southern African Development Community (SADC) (including the SADC Division of Water)</td>
<td></td>
<td>Regional Water Policy, 2005</td>
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<td>Transboundary water management bodies</td>
<td>Orange/Senqu River Basin Commission (ORASECOM) (Botswana, Lesotho, Namibia and RSA). Botswana/RSA Joint Permanent Technical Water Committee; Permanent Water</td>
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<td>The role of the river basin commissions is to foster sustained dialogue between countries, leading to cohesive and effective cooperative management and optimal utilisation of shared resources. They</td>
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Commission (PWC) (Namibia, RSA).

will provide focal points for the joint formulation of development plans for the basin, coordination of joint basin studies, and collection and sharing of information.

<table>
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<tr>
<th>International Organisations and Donors</th>
<th>UN Agencies</th>
<th>International Organisations and Donors</th>
<th>Common to all three countries</th>
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<th>Common to all three countries</th>
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<tbody>
<tr>
<td>International NGOs</td>
<td>UNESCO (International Hydrological Programme) ; UNEP ; FAO ; World Bank</td>
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<td>Global Water Partnership ; EU-Africa Partnership</td>
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<td>International Cooperation Partners (ICPs) eg DANIDA, SDC, GIZ, JICA</td>
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