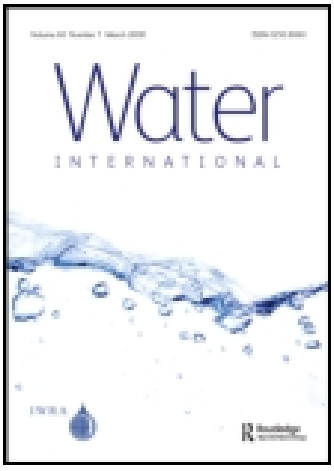

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Vulnerable populations, unreliable water and low water productivity: a role for institutions in the Limpopo Basin

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There are nearly seven million rural people in the Limpopo Basin, many of whom are poor. They rely mainly on unreliable rainfall to support their mixed crop/livestock smallholder production systems. The poor have few avenues out of poverty and are especially vulnerable to disease and continued inequitable distribution of land and water resources. Infrastructure development and other investments target these communities within and institutional support is uneven and under capacitated. Addressing the needs of these populations and achieving sustainable development and livelihood security will take strengthened institutions working closely with the rural poor to meet their needs in the face of ongoing economic, political and climatic change.

Keywords: Limpopo; rural poor; inequity; vulnerable smallholders; productivity; institutions; river basin

Introduction

The Limpopo River basin in southern Africa, one of 63 internationally shared river basins on the continent, encompasses rich natural resources and biodiversity. The basin has 11 main sub-basins, covers 414,800 square kilometres (Wolf *et al*. 1999) and has a population of just over 14 million. Four major metropolitan areas fall within or near the basin – Bulawayo, Gaborone, Polokwane and Johannesburg-Pretoria – which together comprise about half the total basin population.

Portions of four countries make up the basin, with Botswana to the west, Zimbabwe to the north, Mozambique downstream to the east, and South Africa to the south. The latter covers nearly half the basin area, but none of the basin countries has more than 16% of its national surface area within the basin (Figure 1).

Geography

The main river course runs for nearly 1750 kilometres from the source to the mouth. Altitudes range from over 1600 m in the Drakensberg Mountains of South Africa, to sea level where the basin meets the Indian Ocean near Xai-Xai in Mozambique.

The basin has warm summers and mild winters, but temperatures vary widely, depending on altitude and proximity to the coast. Daily mean temperatures in the south and west of the basin range from 5°–10°C in the winter with frosts, and from the mid to the upper 30s

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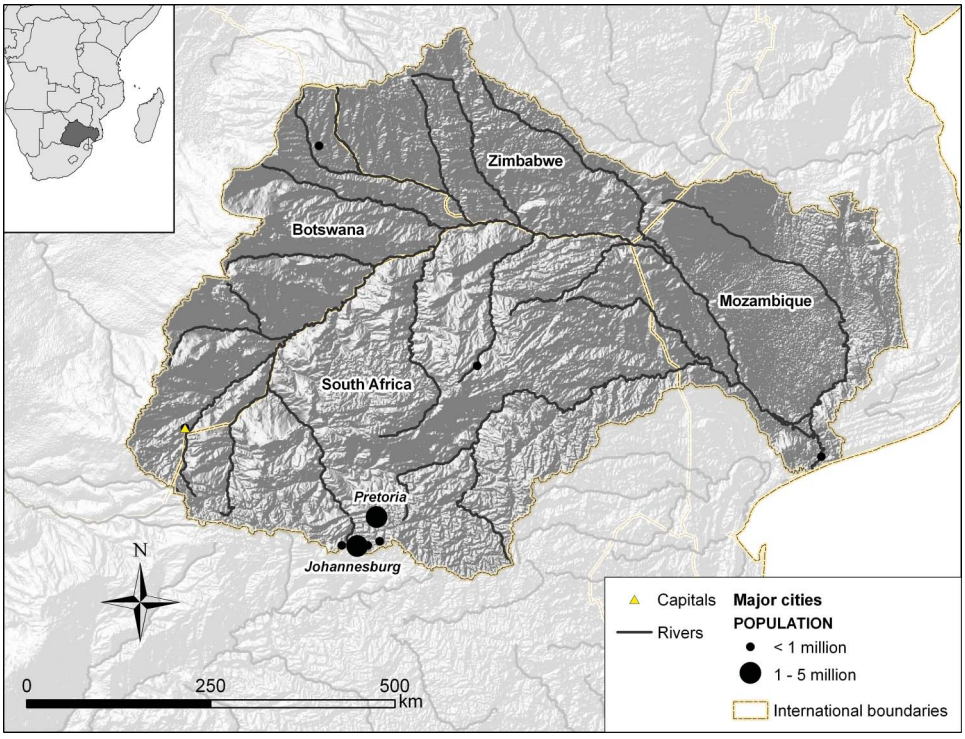

Figure 1. The Limpopo River basin.

in the summer. The northern and eastern parts of the basin are generally warmer because of their low altitude and the influence of the Indian Ocean.

A large portion of the basin falls within the Savannah Biome, known locally as the "bushveld". Its vegetation is characterized by a grassy ground layer and a distinct upper layer of woody plants. A major factor delimiting the biome is the limited rainfall, which, coupled with fires and grazing, allows the grass layer to remain dominant.

The colonial heritage

Countries of the Limpopo Basin have long and well-documented colonial histories, largely shaped by the Dutch, English and Portuguese. For nearly four centuries, policies, institutions, economies and settlements were all directed toward exploiting the natural and the human resource base of the indigenous populations for the benefit of the colonizers. Great wealth was generated in rural areas from mining and agriculture, but little was returned to develop either the human resource or rural infrastructure.

Poverty and policy

Poverty in the Limpopo Basin is concentrated in rural areas where populations rely largely on the natural resource base for their livelihoods. Poverty is higher amongst households headed by women than in those headed by men, mainly due to gender bias in access to productive resources. Low smallholder productivity and poor access to credit exacerbate the high levels of poverty. Unemployment, poor access to water and low levels of education prevail, leading to low income, compromised health, and few economic opportunities.

In response, national policies in all four basin countries have focused on poverty reduction, using various strategies such as public sector reforms, environmental protection, integrated rural development, human resource development, disaster management, land and natural resources development (including water resources, small-scale agriculture and irrigation), HIV and AIDS prevention, and empowerment of women.

Despite implementation of policy reforms and interventions in all four countries, both poverty and inequality remain high in the basin. Where there has been rapid economic growth, its benefits have been spread unevenly across the basin population. The highest incomes are enjoyed by those in formal sector employment, but they make up less than half of the labour force. The remainder are less well off, being engaged in the informal sector and subsistence agriculture, or unemployed. Low incomes, and hence high poverty rates, are concentrated in the rural areas, where economic growth has stagnated for many years. A number of factors contribute to this situation, including limited alternatives to agriculture for economic development in rural areas, which ultimately limit investment in education, health care and other basic services.

Historically, the rural poor in the basin were relegated to water-scarce areas. Although it is often difficult to establish causality between water scarcity and poverty, the association is quite clear in many parts of the Limpopo.

Vulnerable populations

Population distribution

While Botswana, Mozambique and Zimbabwe each has about one million basin residents, the relative proportion of the national population living in, and relying upon, the Limpopo Basin varies widely across the four countries, from 59% in Botswana to less than 10% in Mozambique and Zimbabwe (Table 1). Almost 60% of the basin's rural population lives in South Africa, followed by Mozambique (15%), Zimbabwe (13%) and Botswana (8%).

Resources

A general characteristic of the basin is that it lacks outstanding features, in that the river itself does not serve as the focus for any large city or major industry. The river mouth is not a harbour, nor is the river navigable in any important sense. Thus, while at certain points the river serves as a boundary between South Africa, Botswana and Zimbabwe, it does not, *per se*, generate a great deal of local activity.

Table 1. Distribution of population in the Limpopo Basin by country.

Country	Population of country in basin	Fraction of country's population in basin	Country share of total basin area	Fraction of country area in basin	National rural population as % of total in 1998	National rural population density (WDI 2008)*
	million	*%*	*(%)*	*(%)*	*%*	*/km²*
Botswana	1.0	59	19	14	31	230.8
Mozambique	1.3	7	21	11	62	307.9
South Africa	10.7	24	45	15	50	125.1
Zimbabwe	1.0	9	15	16	66	253.7

Source: Compiled from United Nations Development Program (2003).
* Data for 2003 for comparison.

Settlement patterns across the basin have been heavily influenced by mining and the availability of water. The inequitable distribution of land, water and economic resources left over from four centuries of European settlement manifests itself in pockets of extreme wealth in urban centres, and high productivity of commercial farms, juxtaposed with much larger pockets of poverty, particularly in rural areas, which are characterized by dispersed settlements that have low annual rainfall on degraded land.

Countries within the Limpopo Basin depend on its natural resources for agriculture, tourism and industry (mainly mining), which account for up to 50% of their GDP (WDI 2008). Unfortunately, countries with abundant natural resources, such as oil and minerals, are much less likely than others not so endowed to include the poor in their economic growth strategy and policies (Sachs and Warner 1995). For example, the resource-rich countries of central Africa are among the poorest in the world. The Limpopo Basin is no exception: although mining is a major economic activity, rural poverty is widespread. It is particularly deep on both sides of the Zimbabwe–Mozambique border in the northeast of the basin, and in the areas of South Africa formerly designated as homelands.

In these areas, nearly 80% of the rural people live on less than US$1 per day and unemployment is very high, with education, health care, infrastructure and access to clean water correspondingly low. Mozambique has the highest national population below the poverty line of a dollar a day among the four basin countries, with nearly 38%. Zimbabwe has 36% and Botswana has 33.3% of its entire population living on less than a dollar a day. A 2005 study showed that 40% of black South Africans lived on less than $2 per day while poverty had increased from 36% in 1995 to 47% in 2000 in the Limpopo Province within the basin (Hoogeveen and Özler 2005).

Economic history

Divestment away from smallholder agriculture and investment in large-scale commercial enterprises has changed the face of farming in parts of southern Africa in the twentieth century. Remnants of that change, combined with many other factors, are still visible in statistics about the size and composition of each country's agricultural labour force. Agriculture still employs a majority of the population in both Zimbabwe and Mozambique, and nearly half (45%) of the population in Botswana (Table 2). That only 10% of the South African labour force was engaged in agriculture in 1998, and nearly 75% of them were men, which is a departure from the regional norm, reflects the highly commercialized and mechanized nature of the agricultural sector in that country.

Table 2. Size and composition of the agricultural labour force in the Limpopo Basin.

			Agricultural labour force			
Country	1998 population	Total labour force	Number	Fraction of total	Male	Female
	million	*million*	*million*	*%*	*%*	*%*
Botswana	1.6	0.67	0.30	45	43	57
Mozambique	16.5	9.59	7.72	81	43	57
South Africa	42.1	18.03	1.73	10	74	26
Zimbabwe	11.4	5.63	3.52	63	47	53

Source: Challenge Program for Water and Food (2003).

Men from rural communities in southern Africa have long been seen as sources of labour, and were often directly or indirectly coerced to work in mining, industry and other economic sectors. Their participation in the labour market introduced remittances to the rural areas, thereby contributing to reduced household reliance on agricultural activities.

The combination of rural communities left with limited available labour and expulsion from communal lands changed the role of agriculture in household survival strategies across large parts of the South African and Zimbabwean portions of the Limpopo Basin. Subsistence farming remains a vital livelihood activity in large areas of the basin but the value of small-scale agricultural production has decreased. Poor land-use management has led to degradation of the natural resource base and women, who often found themselves as the sole provider present in the household, were left to farm the land with little or no technical or economic support.

Not all the poor depend on agriculture for their livelihoods, but the majority in Mozambique and Zimbabwe do. The actual number fluctuates across basin states, depending on a number of regional factors. Other livelihood options include social grants, remittances, trading, home-based businesses, and sporadic local employment, which suggests that agriculture cannot be a ladder out of poverty for all. Nevertheless, despite the weight of historical, economic and hydrological factors against them, there are still smallholder farmers in rural communities. Their sources of water are boreholes, shallow hand-dug wells, small reservoirs, rivers, streams and irrigation canals. However, they lack adequate road access to economic centres, water and sanitation systems, and municipalities with the capacity to deliver services.

Like the majority of the rural people, basin residents have low household incomes and purchasing power, while high levels of illiteracy and HIV/AIDS exacerbate the situation (South Africa, Department of Agriculture, 2006). Given uneven development and distribution of wealth, the current conditions reflect institutional unwillingness and inability to target strategic interventions to address poverty, HIV/AIDS, food insecurity, environmental degradation and competing interests. This results from the history of political and economic policies (apartheid, forced migration, labour extraction and civil war) that have shaped the development trajectory of the basin. Their profound effect on settlement patterns and resultant poverty is difficult to overestimate. We discuss this aspect in more detail below.

Income distribution

Mozambique is by far the poorest of the basin countries, and the one whose residents are most likely to be malnourished (Table 3).

Table 3. Gross domestic product (GDP), income, distribution and nutrition in the Limpopo Basin.

Country	GDP per capita	Population <$1/day	Gini index	Income share of lowest 10%	Income share of highest 10%	Undernourished people
	2005$	*%*	*%*	*%*	*%*	*%*
Botswana	7,423	33.3	63.0	0.7	56.5	23
Mozambique	376	37.9	39.6	2.5	31.7	54
South Africa	6,293	11.5	59.3	1.1	45.9	–
Zimbabwe	1,617	36.0	50.1	2.0	40.4	39

Source: Adapted from Hanjra and Gichuki (2008). South African statistics on nutrition not available.

In South Africa, inequitable distribution of income is well known, with small concentrations of extreme wealth contrasted with the poor majority, which is confirmed by a Gini index of 59.3 (Table 3). In Botswana, income distribution is more skewed than elsewhere in the basin, which reflects the dependence of the Botswanan economy on diamonds and the poverty in the arid rural areas — although the country is often cited as an economic success, its economic growth has bypassed the rural poor. Zimbabwe is much poorer and has a somewhat less skewed income distribution.

Estimates in rural Limpopo by Perret *et al*. (2005), show 70% of households living on less than US$227/month, and 40% living with less than US$125/month. Rural populations in Botswana survive on 37% of the average household income of their urban counterparts.

Rural poverty

Rural poverty can be assessed through a rural livelihoods approach, which examines other factors in addition to income. This approach suggests poverty is often correlated with certain vulnerable groups and that women and children are disproportionately over-represented among the ultra-poor (those living on less than $0.50/day). The ultra-poor represent the most alarming cases of deep monetary poverty, associated with isolation from the local social fabric and health problems such as HIV/AIDS. Living conditions in rural areas are much worse than in urban areas, and the rural poor are rarely heard at national policy level.

Persistent rural poverty in the Limpopo Basin has outlasted a variety of political and economic initiatives and needs a closer look. While data such as those from a human development index (HDI) or a water poverty index (WPI) are useful for comparison, they do not necessarily expose the combination of underlying causes that keep successive generations of rural families in poverty.

The HDI is a composite index based upon life expectancy, literacy and schooling, and standard of living. United Nations data from 2007 (United Nations Development Programme [UNDP] 2009) rank Botswana as the tenth most developed African country, and Mozambique as having the lowest HDI in Africa. South Africa falls below Botswana and data from Zimbabwe have not been available for several years.

Water poverty index (WPI) is an aggregate index, which describes relative scarcity of fresh water at a country level. The WPI from 2002 (World Resources Institute 2006, UNEP/GRID-Arendal n.d.) shows Mozambique as having a very low WPI (fresh water is abundant), Zimbabwe and South Africa as low (there is little scarcity of freshwater) and Botswana, which is the driest country in the basin, as having a medium WPI, that is, freshwater is moderately scarce.

Despite seasonal and periodic water scarcity in the Limpopo Basin, water availability is not a source of conflict between the four riparian states. Each country faces essentially the same major issue within its borders: how to prioritize development and allocate highly irregular natural resources, namely water and land, in the face of historical inequalities and great economic potential.

Water-consumptive land uses

The land uses that consume rainfall (Figure 2) are roughly proportional to the area of the basin that they cover: grassland covers nearly 57% of the basin land area and uses 54% of the rainfall, and rainfed agriculture covers 40% of the land and uses 40% of the water. Mining uses less than 5% of basin water but almost certainly impacts the quality of the

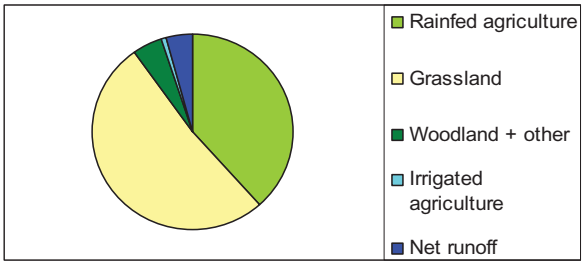

Figure 2. Land use/land cover in the Limpopo Basin.
Source: Adapted from Mainuddin *et al*. (2010).

water resources. Irrigated agriculture covers only 0.6% of the land area and diverts less than 1% of surface water, but is critical to those farmers who rely upon it.

According to water productivity analysis done under the Limpopo Basin Focal Project in 2010, most of the basin's water resources support shrub or grassland. Although agriculture occupies a relatively small portion of the basin area, large numbers of small-scale farmers are found throughout the basin, often on degraded soils with unreliable rains.

Irrigation is practised in some of the commercial and communal lands. While it usually has a much higher yield than rainfed cropping, there are vast differences between large-scale commercial irrigated operations and small-scale infrastructure. At least 300 small-scale irrigation schemes have been developed in the basin over the last 40 years but they now function poorly or not at all, after neglect, abandonment or management regimes that have changed with the profound political changes that have occurred.

The main land use in the Limpopo Basin, in terms of both the population and the land area involved, is mixed crop and livestock farming. The rural poor in Zimbabwe and Mozambique rely on the rainfall for both types of farming, a precarious livelihood. Their counterparts in Botswana and South Africa have the added option of social welfare grants, and are less likely to engage in agricultural activities, especially in drier areas. Agricultural production is either large-scale commercial production, or the small-scale mixed crop/livestock systems on communal land that dominate the smallholder sector.

The term "small-scale" often refers to the scale of economic investment as well as to the physical size of the operation, in the sector where the farmers are called "smallholders". At the lower end of the smallholder scale is subsistence agriculture, which contributes little to national agricultural outputs and primarily provides food for the household, but may provide food for sale when they have enough surplus or when they need money.

Subsistence agriculture

Subsistence farmers generally have limited access to input and output markets, but many in Zimbabwe have access to improved seeds through a well-developed distribution network (Bourdillon *et al*. 2007). Elsewhere, they rely on their own saved seed or on local sources of typically low-yielding varieties. Output marketing is often limited to local markets, or through parastatal institutions for cash crops such as sunflowers or cotton.

As elsewhere, subsistence agriculture in the Limpopo Basin is a low-input-low-output system that seeks to minimize risks caused by climate variability, and to make the most of limited resources. It is characterized by minimal use of inputs such as fertilizer and

certified seed, and low levels of management. Its performance is restricted by insecure land tenure, low-level technologies, risky water supply, and limited access to other production resources, such as labour and cash. Moreover, the soils are often degraded and depleted of nutrients. Subsistence farmers in the basin typically crop small areas because they rely on hand-hoeing and family labour. This often leads to land preparation being delayed, increasing their risk of crop failure if rains arrive on time.

Livestock farming

Livestock production in the basin as a whole is economically and socially important. Subsistence farmers' livestock are typically managed in low-input systems of extensive grazing on poor quality feed in a variable climate. The stock access surface water or water provided via windmill, hand pump or other mechanism. They graze communal pastures during the day and are guarded in *kraals* at night. Milk production, which is used primarily to meet household needs, is low. On the other hand, large-scale commercial farmers with greater access to resources and secure tenure maximize productivity in intensive systems.

Figures from Botswana suggest that returns from livestock, mainly meat exports, contribute 2.6% of the 3% GDP contribution from agriculture (Republic of Botswana, Central Statistics Office 2004). Livestock numbers remained more or less constant over the decade to 2003, but fell by 30–40% in the drought year of 2004.

In South Africa, animal products contributed 45% to total agricultural production in the 1980s (Food and Agriculture Organization [FAO] 2004). Livestock outputs (meat, milk, eggs, skins, and so on) in Mozambique accounted for 25% of agricultural domestic product in the 1990s (FAO 2004). According to the famine early warning system network (FEWSNET), livestock numbers and production in Mozambique have been increasing since 1993 (FAO 2004). In 2003, Limpopo Province, which makes up the bulk of the Limpopo Basin in South Africa, had 1.23 million cattle (nearly 9% of the total national herd), of which 458,000 were in commercial areas and 775,000 in communal areas (Limpopo Province Freight Transport Databank). Nationally, about 60% of cattle are fattened for slaughter.

Livestock are crucial to smallholders' livelihood security, acting as a buffer against economic shocks. They also have cultural significance, because ownership of livestock is an indicator of wealth. Cattle are used to pay a bride price, to acquire and store wealth, to spread the risk in mixed farming systems, as draught power, and for meat and milk.

Nearly 70% of cattle, sheep and goats in southern Africa are kept by smallholders (FAO 2004), most of whom also keep chickens. In general, men own and manage cattle and goats, which are more important to the household. Women tend to own and manage the small livestock such as chickens and ducks. Smallholders mostly have local breeds of cattle that are generally well adapted to the basin conditions of high temperatures, low-quality diet, and ticks and other parasites, but their reproduction rates are poor, with a 24-month calving interval as opposed to 12–15 months in intensive systems (De Leeuw and Thorpe 1996).

Herd size and overall animal numbers are affected by the frequent droughts in the basin, which reduce fodder quantity and quality, and water availability. Cattle are typically kept in small herds of less than 10 head in Zimbabwe and four to 10 in Mozambique (International Fund for Agricultural Development 1996). In Botswana, herd sizes are relatively larger than in the other basin countries, with a 1996 estimate of just over 44 (FAO 2004). However, demographic pressure has decreased the number of households in Botswana that own cattle, while ownership of goats, sheep and chickens has increased (Low and Rebelo 1996).

Movement of stock as a drought-avoidance strategy is hampered by land tenure structures and also because severe droughts generally affect large areas. Yet farmers in many parts of the basin are reluctant to sell cattle to reduce stocking rates, preferring to maximize herd size as a safety net for use in times of drought (FAO 2004).

Crop farming

Rainfed cropping is the predominant crop production system in the basin, in spite of the high aridity, because of favourable temperatures and ample annual solar radiation. Potential production of crops is constrained mainly by rainfall and soil fertility. The supply risk of agricultural water is therefore a crucial issue for crop farmers in the Limpopo Basin. As the simulated rainfall pattern shown in Figure 3 suggests, the probability of crop failure due to drought is a constant threat.

The main rainfed crop is maize, with lesser amounts of wheat, sunflower, citrus, potatoes, and dry beans. Crop productivity in the basin reflects historical patterns, with yield differences caused by differences in production technologies and rainfall. South Africa is the only country in the basin in which maize yields have increased during the last 40 years. The average yield is about 3600 kg/ha but varies widely, from less than 1000 kg/ha in subsistence systems to over 8000 kg/ha in intensive commercial farms (Hanjra and Gichuki 2008). Average maize yields in the communal sector is only 250 kg/ha in Botswana and about 800 kg/ha in Zimbabwe (Hanjra and Gichuki 2008).

Given the widespread adoption of improved technologies and high yields in the commercial sector across all the basin, it is clear that it is not the availability of technology that limits smallholder production. The issue seems to be that smallholders do not have the access to markets and infrastructure that would allow them to use the technology that is available. A corollary is that technology alone is not the answer. Policies like water rights, land tenure, and subsides also play a vital role. We discuss some of these aspects below.

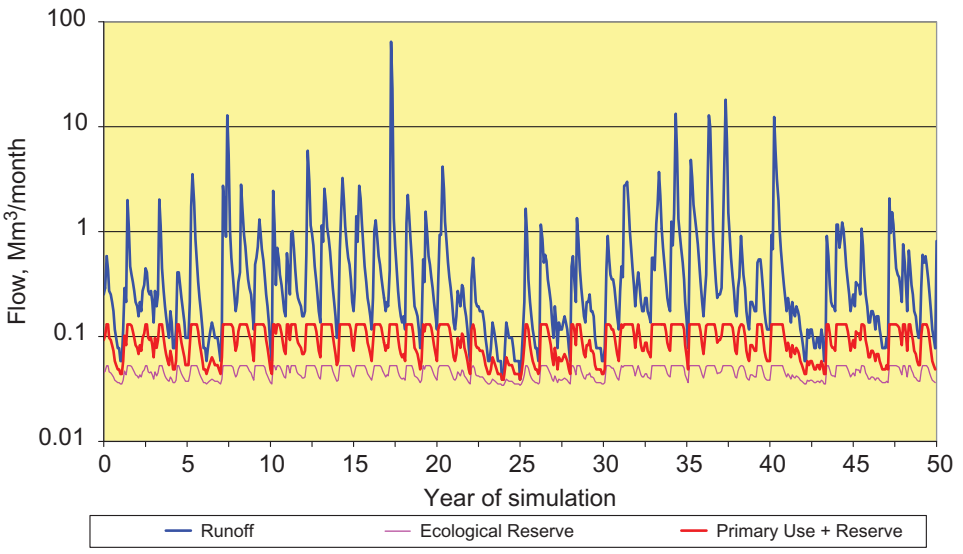

Figure 3. Runoff hydrograph – 50-year simulation – Crocodile sub-basin.
Source: Limpopo Basin Focal Project (2010).

Water in the Limpopo Basin

In a water-use account of the basin, Mainuddin *et al*. (2010) used an area of 412,900 square kilometres. Rainfall input is 230 km^3/yr with a mean annual discharge of 3.6 km^3 at the mouth, 1.6% of the total precipitation input. Rainfall varies from 200 millimetres to 1500 millimetres, with "much of the northern and western parts of the basin receiving less than 500 millimetres. Rainfall is highly seasonal, with 95 percent falling between October and April. The rainy season is short with the annual number of rain days seldom exceeding 50. The consequence is that the Limpopo and its tributaries have a very pronounced seasonal variation in flow, with negligible flows in the dry season" (Mainuddin *et al*. 2010). Rainfall varies considerably from year to year. Mean annual rainfall in the basin is less than 550 mm. Floods and droughts occur frequently, and intra-season variability makes farmers vulnerable to crop failure and livestock loss.

We divide water use into runoff, ecological reserve and primary water requirements. A hydrograph of typical river flow in Figure 3 illustrates how these water uses are prioritized in the Limpopo Basin. Within the water sector, agriculture is rarely recognised as a separate water use and is not prioritized. This is because, although rainfed agriculture (including livestock) supports most of the rural population, it carries a low water cost to the state so its role in rural development is not viewed as a water-related issue.

The ecological reserve or base flow is the water that must remain in the river system to preserve ecological functions. This need is met first from the most readily available water. The second water use to be met is known as "primary water requirements", which includes domestic and industrial uses. Agriculture accesses the water that makes up the difference between the primary use and the runoff (between the upper two lines in Figure 3). Yet the peaks in the upper line represent the rainfall that exits the basin quickly as flood flow, so that vast quantities of water are not captured and are unavailable to agriculture.

There are 250,000 ha of irrigation in the basin (FAO AQUASTAT 2004), which accounts for less than 1% of the total drainage area. There is increasing uncertainty about its environmental and social costs, however. There is no objective analysis of irrigation that identifies the environmental costs, the economic benefits and the complete list of beneficiaries.

Irrigated agriculture relies mainly on the "high-risk" water that comes in as an unpredictable and temporary excess flow. Supply risks can be mitigated to a limited extent by providing storage that converts some of the surplus flow into a more usable format. Converting surplus water (floodwater) does not, however, guarantee water for irrigators because shortages in the primary and ecological reserve supplies must be satisfied first.

It must be noted that water for domestic and industrial use is considered a priority in the basin, and so must be supplied from reliable sources. Irrigation water is given a lower priority and often comes from less reliable sources, leading to frequent water shortages.

Water demand

Table 4 shows current water distribution between sectors in each country. Water demand within the basin continues to grow. Rural development targets for water and sanitation delivery in all basin countries, as well as land and water reform, suggest that more equitable distribution of existing resources may be closer to a physical and economic reality than at any point in the past. Of course, competition for these scarce resources comes from powerful stakeholders such as commercial agriculture, mining and environmental interests, which will require decision makers to confront very difficult choices. According

Table 4. Water use by sector in the Limpopo riparian states.

Country	Agriculture (%)	Industry (%)	Domestic (%)
Botswana	48	20	32
Mozambique	89	2	9
South Africa	62	21	17
Zimbabwe	79	7	14

Source: SADC (1999).

to the Food and Agriculture Organization (FAO AQUASTAT 2004), at least two of the Limpopo's sub-basins in South Africa are over-subscribed; moreover, there are some inter-basin transfers.

Water availability

Per capita water availability in the basin, a theoretical amount calculated as the total amount of water available divided by the total population, varies widely, ranging from less than 900 m^3/person in Botswana to over 5800 m^3/person in Mozambique. In South Africa and Zimbabwe per capita water availability is about 1200 m^3. These figures are estimates and are useful only for comparison, but it is worth noting that they are likely to decline if climate change predictions hold true.

Ample per capita water availability suggests that water scarcity in the basin may be more economic than physical (Seckler *et al*. 1998). But even when there is sufficient water at a basin scale, it is often not available where poor people can make use of it, nor when they need it most. Nevertheless, water is relatively scarce in the basin, whose hydrology is affected by the extreme climate variability (Scott 2008). Rain falls during a short, intense rainy season, so that the majority of runoff from the basin occurs in short-lived flood peaks. As well as devastating floods, notably in 2000, there are long, severe droughts every 10–20 years throughout the region (FAO CLIMWAT).

Rainfall, evapotranspiration and runoff

Rainfall in the basin is unreliable, both within and between years, which exposes those relying on it to high risk of crop failure. Furthermore, the basin shows a large difference between potential and actual evapotranspiration (Figure 4), which indicates the level of water stress to which crops are exposed.

Upstream areas of the basin (in Zimbabwe, Botswana and part of South Africa) have low rainfall, which severely limits crop yields. However, the downstream and southern areas of the basin suffer relatively less water shortage and, in the South African parts of the southern basin, though not in the Mozambiquan parts, the cropping system benefits from higher rainfall and better-established farming systems.

With up to 80% of the rain falling between November and late February, rarely in more than 50 rainy days, the Limpopo and its tributaries have a very pronounced seasonal variation in flow, and low season flows are negligible. Several factors contribute to this fluctuating water availability, including rainfall, soil type, ground cover and slope. The hydrograph of typical river flow in Figure 3 illustrates how natural runoff (the upper line) can be highly erratic.

About 18% of the basin is classified as arid, with very hot summers, and just over 80% is semi-arid (Figure 5). Runoff varies across the basin, with relatively more water available in the southwestern portion of the basin.

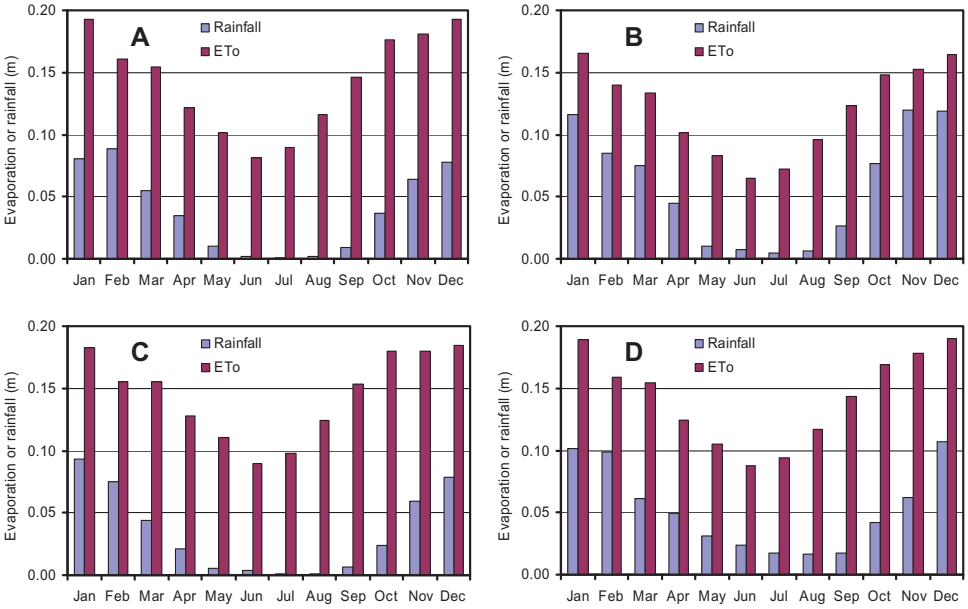

Figure 4. Annual rainfall and potential evapotranspiration at four points in the Limpopo Basin: (A) the Upper Olifants in South Africa; (B) the Lower Limpopo near Chokwe, Mozambique; (C) upstream at Oxenham Ranch in South Africa; and (D) the Tuli catchment in Zimbabwe.
Source: Mainuddin *et al*. (2010).

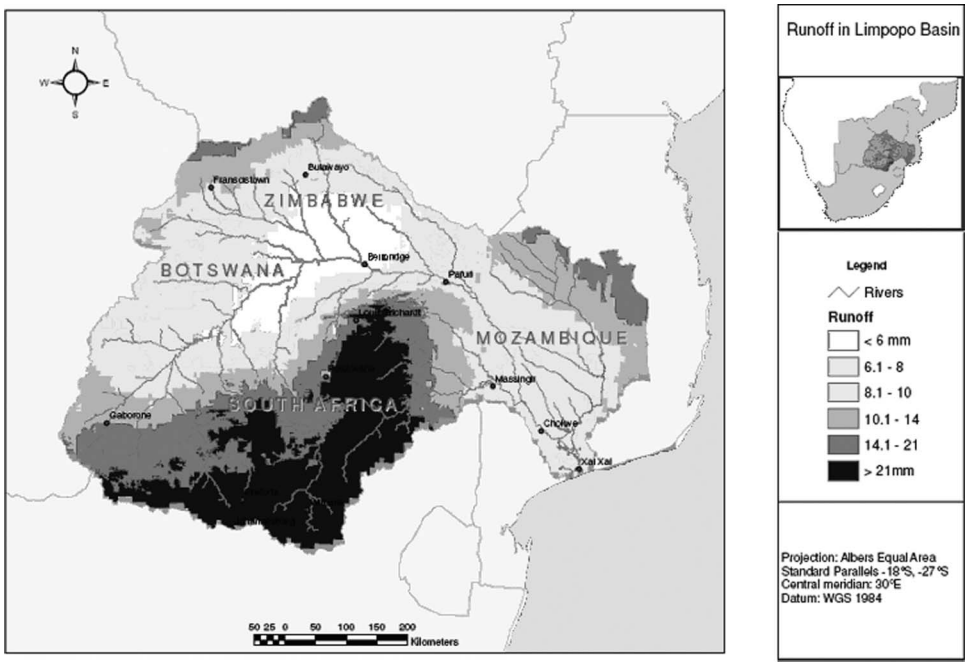

Figure 5. Limpopo Basin run-off map.
Source: Limpopo Basin Focal Project (2010).

Downstream of the confluence of the Shashi and Limpopo, there is a stretch of the river where, when the river is low, water that flows in does not flow out. Mean annual rainfall in this sector is 250–450 mm but evaporation is as high as 2100 mm/yr so that runoff from the surrounding area is negligible. The riverbed in this stretch is normally dry sand, varying from 20–200 metres in width. It is thought that when the inflow is low, there is so much evaporation of the sub-surface water from the sand bed that there is no downstream outflow (FAO 2004, Scott 2008).

Drought

As discussed above, the Limpopo Basin is susceptible to meteorological and hydrological droughts. A "meteorological drought" is defined as an interval of time, generally months or years, during which the *rainfall* at a given place falls considerably below the long-term average, normally also taking account of the balance between rainfall and evapotranspiration. A "hydrological drought" is a period of below-normal *stream flow* or depleted reservoir storage. Taken together, it is clear that meteorological drought may lead to hydrological drought, but not necessarily so.

For water resource planning, three aspects of drought are of interest:

- the duration of a particular drought;
- its severity; and
- the frequency of successive droughts.

The severity of a drought indicates the magnitude of the shortfall in the rainfall and is normally expressed as an aridity index (AI), which quantifies the precipitation deficits for multiple time scales by defining the ratio between mean annual precipitation and mean annual potential evapotranspiration (PET). An AI of 0.2 means that rainfall supplies 20% of the PET (Ezcurra 2006). Lands classified as arid have AIs less than 0.2.

AI assessments across the Limpopo Basin (Alemaw *et al*. 2010) are presented in Figure 6 below, which suggests that aridity is high across much of the Limpopo Basin. This contributes greatly to the vulnerability of the small-scale, rainfed farmers in the basin and helps explain why livestock continue to be a key to rural survival. Small-scale farmers can dispose of livestock for some return during a drought, unlike crop failure, which entails complete economic loss.

Low water productivity

Water productivity (calculated in US$/m^3 water applied) varies across the basin, primarily as a result of variation in the gross value of production of the major crops. Water productivity for the entire basin is patchy and generally low compared to other basins, and is also highly variable. In the Olifants sub-catchment, which is in the South African part of the basin, water productivity is as high as in the Nile Basin (from the 2005 data analysed, South Africa had the highest water productivity of the four riparian states), but water productivity in Mozambique was unexpectedly low despite the low water stress in that part of the basin. This implies that water is not the main limitation to productivity in Mozambique portion of the basin and can likely be addressed through means other than increased availability of water.

Analysis of gross value of production is challenging due to the limited availability of data at the scale of the administrative boundary in some basin countries. Nevertheless,

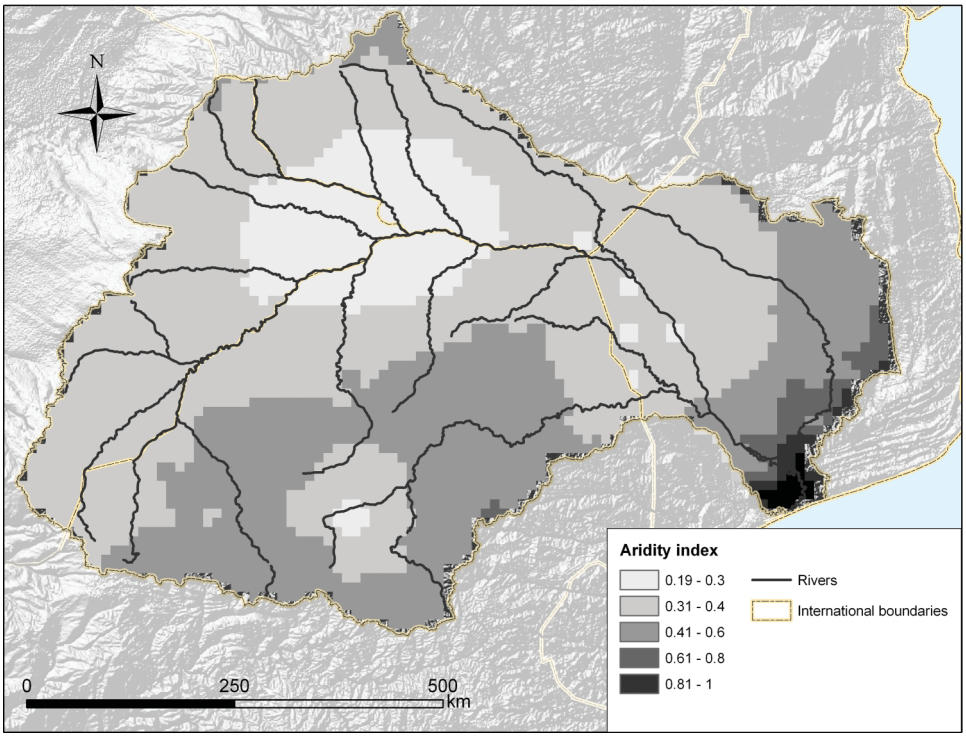

Figure 6. Aridity index map Limpopo Basin.
Source: Alemaw *et al*. (2010).

analysis suggested that the gross value of production of agriculture is the driving factor that determines differences in agricultural water productivity across the basin. The extremely variable water productivity in the basin is mainly due to the significant variation in the yields of different crop production systems. This variation in the gross value of production is caused not only by crop yield variation, but also by the wide fluctuations in market prices caused by the different market conditions in the riparian countries.

Higher agricultural water productivity (more than US$1.00/m^3, such as found in the Olifants sub-catchment) was obtained with crops such vegetables, fruit and tobacco that give a high net return. This suggests that better matching of crops to physical conditions could improve water productivity in this and other areas of the basin. Similar pockets of high-value crop production are interspersed with the generally very low gross value of production throughout the basin. These pockets mostly correspond with large-scale commercial farms that contribute to both national and regional food security, and also to rural employment. They perform relatively better than other areas as a result of higher inputs, better soils, better rainfall and better management practices. However, they use a disproportionate share of the land and water resources.

Poor farmers who cultivate on small-scale communal lands are most vulnerable to the risks of crop failure caused by the frequent droughts. Some of them farm in areas that are least endowed with fertile soils and good rainfall. Yields in these areas are invariably low, and market access is likely limited, resulting in lower gross value of production than in other areas.

Gross value of production

The productivity of crop-based agriculture is measured as gross value of production (GVP), which is a function of yield and market prices. Simply put, GVP is the value of the crop divided by the land area under production. At the basin scale, GVP is highly variable, ranging from US$19.5 to US$368/ha. It is greatest in South Africa, with a range from US$357 to US$368 per hectare. It varies from US$19.5 to US$187 per hectare in Mozambique, from US$35 to US$102 per hectare in Zimbabwe, and from US$50 to US$87 per hectare in Botswana. Much of the variation can be attributed to market returns for crops, which vary widely across the basin due to distance to market, economic and political stability, and crop quality. Low GVP in Botswana is mainly due to the unit of analysis (kg maize/ha). Not much maize is grown in Botswana, where livestock dominate rainfed production.

Climate change

Although water is already scarce in South Africa and Zimbabwe, and Botswana faces chronic water scarcity, it is very likely that there will be further decreases in water availability per person by 2025. Water availability and access in the basin will be affected by climate change and variability, and by the risks associated with planning and managing water and irrigation infrastructure. The latter have important implications for the agricultural water supply of both smallholders and commercial farmers in the basin.

In a pilot study by Jones and Thornton (2002), the weather simulation generator MarkSim (Jones *et al*. 2002) was used to generate 30-year runs of weather data for pixels of 18 kilometres. The generated and the current 30-year weather data and FAO data for all the agricultural soils within each pixel were input to the CERES maize model (Hoogenboom *et al*. 1994) for the variety Katamani Composite B, which is widely grown in the region. The modelled yields were used to generate the yield probabilities. In much of the region, probabilities of yields of 1.5 tons per hectare will be considerably less than current probabilities. Botswana and southern Zimbabwe will go from being risky at present to having almost no chance of producing maize yields from this variety in 2055. Mozambique will go from relatively risk-free production to decidedly risky.

Institutions in the Limpopo Basin

The Limpopo Basin is home to many statutory and traditional institutions that mediate access to natural resources. An emerging basin commission, four national governments, numerous provincial institutions, districts, wards and traditional authorities influence who has which sort of access to what land and water.

Despite a decade of stakeholder participation in integrated water resources management (IWRM), links and communication between decision makers at all levels and end users of the water resources remain weak. Furthermore, the lack of integration between the water, land and rural development sectors, each with its own goals, makes reducing rural poverty even more difficult. Insecure land tenure and water rights not only increase the vulnerability of the rural poor, but also discourage investment in development, and are a direct result of national statutory institutions.

Water governance and control mechanisms are mostly underdeveloped in all four riparian states and, in general, governance of water resources in the region lacks integration. Most countries have national ministries with the responsibility of planning, developing and managing water resources but these ministries are often separate from those that govern agricultural activities or other uses of natural resources, such as mining and tourism.

At the national level, because water resources are scarce, there is competition for water, with high-value interests such as mining and tourism having priority over agriculture. This further increases the vulnerability of farmers to drought and to the unpredictable climate by assigning them the water that remains after all other needs have been met. Moreover, the design of water-supply infrastructure and water allocation are both based on historical data that do not reflect recent or current changes in the rainfall patterns, a policy decision which further disadvantages agriculture. Little investment has been made to deliver available water to those in need, whether for domestic, subsistence or commercial uses.

The institutional environment across the basin is varied in its coverage, capacity and mandate to govern natural resource planning, use and conservation. In addition to sectoral issues (such as water, agriculture, mining and tourism), questions of scale, finance and public participation are particularly relevant within the basin. Current water-related institutions are mainly concerned with sectoral distribution of water for economic gains within nations, but the actual physical distribution is skewed away from the rural poor.

Relationships between countries

Wolf *et al*. (2003) named the Limpopo and other regional basins as being at risk of future conflict over water, but that assessment may not reflect the reality on the ground today. Current relations between the basin states are generally quite positive, with little outward disagreements. This may be due in part to the shared history of liberation struggles of Mozambique, South Africa and Zimbabwe. Nonetheless, Turton (2003) claims that basin hydrological data are contested, with each country promoting data that best represent its own interests.

There are a number of longstanding bilateral agreements between various basin countries. However, the establishment of the Limpopo Basin Permanent Technical Committee (LBPTC) in 1986 was the first recognized basin-wide initiative. The LBPTC focused on short-term water availability issues, division of basin waters, implementation of existing agreements, arrangements for common watersheds and other technical aspects. Recent progress has been made in transforming the LBPTC into the Limpopo Basin Commission (LIMCOM), with a secretariat established in Maputo, to develop a baseline study of the water resources in the basin. Three basin countries have ratified the agreement and Zimbabwe is expected to do so.

Since the relationship between livelihoods and water poverty is influenced by national or sectoral policies and strategies, it is important to highlight selected relevant policies and strategies implemented in each country to provide a basis for analysis.

National development policies

Persistent rural poverty within the basin is a result of history, bio-physical conditions as described above, and national priorities and policies as implemented by institutions. Each basin country has spent the last decades attempting to design and implement development policies to address poverty reduction while stimulating national economic growth, which remains a major challenge across the region.

Botswana

Botswana is not currently considered among the poorest African countries (World Bank 2006). Since the 1970s, Botswana's economy and society have changed from those of a

poor country based on cattle rearing and subsistence agriculture to a more industrialized, urbanized, and developed one, due to the discovery of diamonds. Despite this transformation, poverty and inequality remain high, and the benefits of rapid economic growth have been spread unevenly across the country and between urban and rural populations.

The 1997 National Development Plan 8 (NDP 8) led to rapid economic growth based on exploitation of minerals and the use of revenues derived from mineral production for investment in economic and social infrastructure. The majority of beneficiaries were urban rather than rural dwellers. The ninth National Development Plan (2003–2009) targeted integrated development based on economic diversification, creation of employment and poverty reduction, public sector reforms, environmental protection, rural development and human resources development, including a campaign against HIV/AIDS. Reflecting the limited water available in the Botswana portion of the basin, the focus of the most recent development plan was not on rainfed agriculture.

Mozambique

Over the past decade in Mozambique, the government has created a number of development policies aimed at reducing poverty. The national programme for agricultural development in 1999 (PROAGRI) aimed at transforming the subsistence agriculture sector to market producers. PROAGRI was followed by the plan for the reduction of absolute poverty (PARPA) in 2001 and by PARPA-II in 2006. Their major objective was an integrated strategy to reduce the incidence of absolute poverty to 54% by 2003, and to 45% by 2009, through activities in agriculture, health, education and rural development. A complementary agricultural marketing strategy (ECA) was developed for 2006–2009, with the objective of promoting and improving agricultural marketing, inputs and agricultural services, to stimulate efficiency, equity and transparency by all stakeholders. While the government has made progress, it has yet to reach its targets.

The efforts of the Mozambique government to address water management issues led to the Water Act of 1995, which established basic principles of water management. It provided for improved use of available water resources for all purposes, through sustainable planning to meet the population's needs and economic development. The intended coverage level by the year 2000 was 40% of the national population. This target has not been reached but evidence of rollout of the Act can be seen across Mozambique.

South Africa

In South Africa, 1994 saw transition from racially separate development under apartheid to rural development programmes (RDPs) in a bid to reach the government's development goals. In spite of this partial success, the apartheid legacy remains: 10% of urban households and 39% of rural households still do not have access to basic sanitation services, and 26% of urban households and 23% of rural households do not have access to waste removal.

By 1997, South Africa had abandoned the RDP empowerment strategy for a growth, employment and redistribution (GEAR) strategy. The macroeconomic GEAR strategy included job creation, land reform, housing, services, water and sanitation, energy, telecommunications, transport, the environment and social welfare. GEAR also implied commitment to pro-market policies. The pro-market and welfare approaches have existed in parallel since then, especially in the rural development sector. Their co-existence has not led to significant reduction in rural poverty or improved service delivery to rural areas in recent years.

The government has delegated rural development to decentralized local government, but its concurrent welfare and cost recovery policies contradict the decentralization. Water and sanitation have received high priority and the government has made progress in providing free basic water, but that has meant less revenue to pay for provision of more services, which has hindered progress. South African policies are typically sound with solid rationale, but the human and institutional capacity to implement them, and deliver services to communities, remains an issue.

Zimbabwe

In Zimbabwe, the poverty alleviation action programme (PAAP) has been the main policy framework guiding programmes and strategies earmarked to alleviate poverty. It targets Zimbabwe's poorest rural areas through strategies that aim to improve livelihoods and access to resources, infrastructure and services, as well as increased knowledge. The present status of this and other programmes is difficult to assess, given the recent economic and political crises in Zimbabwe.

Water use and management in Zimbabwe is guided by policies at the national, district and council level. The Water Act of 1998 is the main policy instrument at the national level, guiding access, allocation, use, and management of water resources. Other policies that impact the livelihoods of people in catchment areas include the irrigation policy, drought mitigation policy, the livestock policy and the crop production policy. In addition to these national policies, traditional leadership may put informal institutions in place at the local level to suit the needs and requirements of communities, depending on conditions peculiar to each of them, for instance, the general prohibition of washing of clothes in rivers to preserve water quality.

Social and political turbulence

The last three centuries of natural resources management in the Limpopo Basin have seen colonial construction of nation-states, across existing social, cultural and physical boundaries, which changed the nature of the relationship between populations and the natural resources upon which they depended. Water and land, which used to be public goods under the domain of tribal authority, are now regulated by boundaries, borders and statutory laws dictating access and control. Long-standing agrarian communities have disintegrated as forced migration and the extraction of male labour for mining irreparably changed livelihoods and societies (Earle *et al*. 2006, Tewari 2009).

South Africa, Mozambique and Zimbabwe, with 93% of the Limpopo Basin's population and occupying 81% of its area, have seen dramatic political upheavals in past 40 years, which have profoundly affected the distribution of land, water and livelihoods. The period saw the end of minority governments in South Africa and Zimbabwe, and of the colonial administration in Mozambique. There was civil war in both Mozambique and Zimbabwe. Subsequent fast-track redistribution of farming land in Zimbabwe led to disastrous declines in productivity, 45% malnutrition and severe economic decline. The economy of Botswana, the fourth country of the basin, has been heavily influenced by the recent discovery of deposits of diamonds. The process of change in all four countries is therefore ongoing and the outcomes are uncertain.

Recent basin history cannot be told without acknowledging the integral relationship between access to land and water, and economic and political performance. Current land reform efforts in Zimbabwe and South Africa have had profound impacts on economies

and populations at many scales, and have highlighted the need for institutional integrity in poverty reduction. Adding the burden of water and land reform to already over-burdened institutions serving large rural constituencies may raise frustrations and the pressure on governments to act decisively. The appropriate policies need to be implemented by well-supported institutions that have the mandate and necessary resources to engage directly with rural communities to improve their livelihoods. These two basin countries in particular continue to grapple with balancing the redress of past injustices while maintaining the economic productivity of the available natural resources.

With the spread of independence and democracy across the region in the last 30 years, increased attention was given to rural development through improving agricultural productivity. However, several decades of investment and interventions have not reduced poverty or improved the agricultural productivity of rural populations in the basin to the degree anticipated (Earle *et al*. 2006). As previously stated, agricultural productivity in the basin remains generally low, with small pockets of high productivity. Earle *et al*. (2006) suggest that a key reason for this is the failure of institutions at all levels to enhance and regulate people's access to water.

Lack of access to markets is another barrier that prevents poorer farmers from converting production into higher income. Market prices in the region also fluctuate greatly between countries due to regional social and political turbulence.

Dual economies

Independence and democratization brought great expectations, yet there have been few systemic changes to restructure the economies or the tenure systems that control the exploitation of natural resources. As a result, dual economic systems persist across the basin. On the one hand, there is the commercial sector, with clearly defined rights, which is well linked to markets, infrastructure and technology. On the other hand, there is the communal sector, with insecure rights to tenure, which is relegated to low-input activities with insecure livelihoods. Yet in all the basin countries, both are now under one system of governance, with one set of institutions and policies serving both groups. This clearly does not work. Institutions are likely to continue to be subject to political and financial pressure from powerful established commercial interests, which inevitably seek to protect their favoured status.

Changes in water resources management

African agriculture and management of water resources is being planned and implemented in ways not previously possible. Awareness among decision makers is high, monitoring and capacity building frameworks are in place, and progress is being made. Planning and development processes are being guided by state-of-the-art principles and driven by regional processes that value protection, conservation and efficient use of available natural resources.

Two regional initiatives can be considered quite successful. One, the Comprehensive African Agriculture Development Programme (CAADP), was initiated by the New Economic Partnership for Africa's Development (NEPAD). The other, regional implementation of IWRM, was initiated by the Southern African Development Community (SADC).[1]

IWRM has become influential at the regional and national levels in the riparian states along the Limpopo River, but it has yet to manifest itself as integrated water resources

planning and delivery at subsidiary levels. While there is currently enough water to satisfy requirements, analysis shows that its distribution amongst domestic, environmental, agricultural, mining and tourism uses, varies widely and is not necessarily related to perceived value or benefits. Links between policy, planning and implementation have not lived up to expectations, with the will and capacity to implement lagging behind. Lack of access to water at specific places and times constrains rural development. This is especially true where the costs of water development are high in terms of infrastructure, institutions and markets, such as in the former homelands of South Africa.

An important shift in water resources management principles has been the move away from riparian water rights, especially in South Africa and Zimbabwe. The riparian principle, in force from the colonial period, guaranteed access rights to river water for non-commercial water use by communities, or individuals, who lived adjacent to the river. This principle has been largely replaced by permitted allocation. This exposes productive water users to potentially ponderous regulatory requirements and raises questions about governments' ability to regulate the activities of smallholders. Emphasis has been put on developing plans to manage water resources, and encouraging stakeholder participation in this planning process.

Changes in water resources management across the region aim for harmonization of approaches, and the entrenchment of a regulated system based on authorizing and licensing water uses from a water resource that is regarded as public property. With these regional moves toward IWRM, the traditional view of water as a free basic right poses a challenge for planning and budgeting. All agree that water is, or should be, a basic human right, but on the other hand it is an economic good. Policy makers have therefore adopted the stance that its development and delivery must be paid for by users, because, while the reserve is a guaranteed quantity of water for people and the environment, it still incurs costs. Moreover, water alone is not the problem. Strategic decisions must be made about how much water should be put where, and at what cost to which users.

Capacity building for stakeholder participation

The institutions in the basin have a great need for capacity building, especially at the local level. Although stakeholder participation is a principle of IWRM, current implementation is often unsatisfactory, with domination by elite actors and perpetuation of past inequities in local water-user associations and sub-catchment councils. Without adequate preparation and training, smallholders will continue to lose out in local negotiations for development and management of water resources. Yet improved stakeholder consultation alone will not address the historic inequities or physical water scarcity.

Decision makers must balance natural resources for continued economic growth through industry with secure water and land rights for rural populations. Water resources policies and governance are integral to national development, food security, political stability and stable ecosystems. Yet the links between scarce water and high levels of poverty we document here suggest the need for an integrated approach to water resources planning and development, which focuses on reducing the water-related vulnerability of poor populations and increases their access to secure livelihoods.

Conclusions

Numerous agricultural water management interventions have been introduced in the Limpopo Basin over the last 30 years with limited success. Poverty still persists. Many

strategic intervention packages remain relevant to rural recipients in the basin, but targeting is a major challenge. This paper is a snapshot of the current situation and the recent past. These conclusions are therefore tentative and should be modified as nations within the region adjust their economic and social policies.

Vulnerable populations

The rural poor in the Limpopo Basin rely mainly on rainfed agriculture for their livelihoods, but often live in water-scarce areas and have few resources to invest in developing hydraulic property. Insecure land tenure and water rights increase their vulnerability and discourage investment in development. Yet, for those without the safety net of other options such as grants, agriculture remains their only possibility for livelihood. Improving agricultural productivity is therefore their only possible ladder out of poverty.

Other options include social grants, remittances, trading, home-based businesses and sporadic local employment. Without intervention, many are likely to abandon agriculture as a means of livelihood, which could negatively affect the productivity of the area. However, intervention to reduce rural poverty is extremely difficult because of the lack of integration between the water, land and rural development sectors, each of which has its own target or its own goals.

Given agriculture's role in rural development and poverty reduction, allocation of water for agriculture should be re-examined by each basin country in an effort to reduce supply risks for agricultural producers. This implicates the policy, budgeting and planning arms of government to prioritize risk reduction as an important step toward poverty reduction. It may be, however, that the approach of Botswana and South Africa of providing safety-net grants for the rural poor is the most viable option where the limited overall supply of water can be more productively used elsewhere. As long as this decision is taken transparently, with adequate consideration of the needs of all stakeholders, and the rural poor in particular are provided with adequate livelihoods, there could be little dispute. Further discussion of this aspect is outside the scope of this paper.

Unreliable water

Water is scarce and, to cope with drought and an unpredictable climate, farmers only receive the water left over after all other needs have been met. The design of the water supply system uses outdated data that do not incorporate recent or future changes in the natural resource base and climate. Reducing agricultural vulnerability is especially important given the high levels of rural poverty and the limited capacity of poor communities to deal with droughts and water shortages. Irrigation consumes less than 1% of rainwater in the basin but may have undetected environmental and social costs, such as increasing inequity. Objective analysis is required to identify variations in the costs, benefits, and beneficiaries of irrigation.

There is evidence to suggest that the existing irrigated area in the South African portion of the basin (198,000 hectares) already exceeds its potential by nearly 67,000 hectares (FAO AQUASTAT 2004). On the other hand, Mozambique and Zimbabwe have barely tapped their theoretical potential for irrigation. Policy makers and planners in those two countries can include further development of irrigated agriculture in their potential activities, whereas their counterparts in South Africa are under domestic political pressure to reallocate water away from licensed users to previously dispossessed recipients. Further irrigation development in South Africa is likely to be scrutinized.

Low water productivity

At the meso-scale, low water productivity probably results from poor infrastructure and linkages to markets, given that a wide range of productivity enhancing technologies are available in the region.

While all four countries have policies aimed at supporting small-scale farmers to increase their productivity and profits, the effectiveness of implementation varies considerably. The major issue hindering implementation of IWRM is secure financing to meet long-term goals and to build institutional and technical capacity (SADC 2007). Although IWRM focuses on water, other development sectors in all four basin countries have similar issues.

Widespread rural development and poverty alleviation would strengthen all the relevant sectors (water, agricultural, rural development, environment, education and health) so that the required multi-sectoral approach could be successful. Specific issues include improved market access through better infrastructure; increased rural education and ability to absorb education and capacity building and training efforts; commercial orientation of small-scale enterprises; and subsidized inputs when necessary.

Interventions

Smallholders in the basin, who depend on agriculture for their livelihoods, face a host of ecological and economic challenges. Intervention packages, ranging from technologies to institutions, could be tailored to address their priority needs, but it would take a concerted, combined and co-ordinated effort on the part of regional and national bodies to make their development a priority. All basin countries now have development targets to provide rural water and sanitation, as well as land and water reform, which suggests that a more equitable distribution of existing resources may be closer to reality than at any time previously.

Improved stakeholder consultation will help but will not address historic inequities or physical water scarcity. Decision makers must balance natural resources for continued economic growth through industry with secure water and land rights for rural populations. Water resources policies and governance are integral to national development, food security, political stability and stable ecosystems. Yet the links between scarce water and high poverty we suggest here should focus attention and investment on getting water to people.

On-farm interventions alone are insufficient, an enabling environment of policies, infrastructure, investment, and markets must exist for sustainability. Rural water pricing, permits, and cost-recovery policies must be carefully considered and synchronized with rural development policies so that they do not compromise the economic viability of smallholders.

Competition from powerful interests, such as commercial agriculture, mining and the environmental lobby, however, will require institutional integrity in poverty reduction to enable decision makers to make difficult decisions. While water scarcity in the basin is more economic than physical (Seckler *et al*. 1998), it is often not available where poor people can make use of it, so there must be trade-offs. Regional policy analysis and support bodies have roles to play as this process evolves across the region and basin countries.

Benefit sharing

There are examples of countries that transformed themselves by the equitable distribution of the riches derived by development of natural resources. For example, Sweden

transformed itself from a poor to a rich nation in the last century by exploiting its forests and iron deposits and investing the derived wealth in initiatives like free education and health care. In doing so, it converted its natural resource wealth into human capacity, while it transformed resource extraction into industry and processing, which provided work for its skilled, well-educated labour force (de Vylder 1996). The wealthier basin countries, Botswana and South Africa, could emulate this model by investing returns from national resources in the further development of their rural populations. Ensuring free education, health care, basic services and infrastructure would increase the capacity of rural populations to help drive economic development.

In contrast, countries without natural resources only have their human resources to develop and they have to do this by focusing on the education and creation of a highly productive, skilled labour force. In such cases, typified by Switzerland, Japan and Hong Kong, the countries' economies then attract investment and grow. A key issue is the political will to distribute the benefits, such as health care and pensions. Cultural homogeneity and historical opportunity also appear to be important.

Basin-level planning and management can be taken sequentially or holistically. A sequential approach has each entity planning for its portion of the water, and how best to meet its needs and maximize its potential. Holistic planning allows for an approach commonly referred to as benefit sharing (Sadoff *et al*. 2002, Turton 2008). Benefit sharing treats the resource as a whole and encourages actors to explore how best to generate overall benefits, and share costs and benefits in a mutually agreed-upon manner. It calls for planning and development agents from riparian countries to think beyond the water flowing across their borders, and think of a cascade of benefits whereby the actual volume of water represents one of many possible benefits. Examples of benefit sharing from water have recently emerged from the Andes basins and the approach is gaining traction at a transboundary scale (Turton 2008).

The benefit-sharing approach to river basin management suggested by Turton has been practised, in small ways, within the Limpopo Basin. This approach to maximizing benefits to be shared equitably could ease current pressures on the resource and act as a buffer against the climate, economic and political changes so common in the region. At the basin scale, the LIMCOM could play a vital role in overall basin assessment, monitoring and planning for the purpose of benefit sharing.

On a cautionary note, it must be said that LIMCOM is currently dominated by water sector professionals, which does not bode well for integrated planning and development of basin water resources. Furthermore LIMCOM has yet to reach its potential as a multinational co-ordinating authority.

Recommended roles for institutions in the Limpopo Basin

Future development of the Limpopo River basin will depend heavily on the effectiveness of the institutions charged with meeting competing needs.

In production technologies

This study has shown high productivity potential in the Limpopo Basin when natural resources, infrastructure, market linkages and technologies are present. Rural populations relying on agriculture in the basin should adapt their production systems to prevailing conditions (wet or dry) and take advantage of existing and emerging technologies. For example:

(1) The Consultative Group on International Agricultural Research (CGIAR) and SADC are promoting conservation farming research and implementation within the basin, mainly for dry areas;
(2) Rainwater harvesting techniques, from household to field level, should be combined with value-chain and finance facilities to improve productivity. These strategies may include small reservoirs and other water storage techniques; and
(3) In areas with ample water, focus needs to be on market linkages, value chains, and increased competitiveness.

There is potential for:

(1) Increasing water-use efficiency at the farm level and reducing runoff from the system. This must be balanced against the effect on the amount of water available for storage. These issues are site-specific and require further research to determine the best mix of approaches and technologies for increasing productivity while improving water-use efficiency of the whole system;
(2) Improving agricultural productivity in the basin by enhancing and regulating people's access to water;
(3) Improving water productivity by better matching of crops to physical conditions, especially in Mozambique where water is less scarce but productivity is lower than in the rest of the basin; and
(4) Assessing the current livestock production strategies in relation to natural resource availability to increase productivity in this sector. Livestock plays a crucial role in rural livelihoods in the basin, yet is often overlooked as a strategy to reduce poverty.

In irrigation productivity

Irrigated agriculture supports a small proportion of the rural poor in the basin but there is scope in most areas to increase the productivity of irrigated crops:

(1) Institutional collapse is cited as a frequent cause of failure of interventions in the basin. Therefore, increased attention needs to be paid to capacity building for local level water management;
(2) Water supply risks for irrigation schemes need to be calculated and analysed before scarce financial resources are invested in schemes that are likely to run out of water;
(3) Several hundred small-scale irrigation schemes in the basin, mainly in South Africa and Zimbabwe, are in need of rehabilitation. South Africa has started such an effort, and the lessons learned should be derived and used to expand this activity to other areas;
(4) There is limited potential for new irrigated areas in Botswana. This should be explored, most likely in conjunction with high-value crops or animal fodder to support existing production activities; and
(5) There is considerable room for expanding irrigation in the wetter parts of the Mozambican basin, but natural hazards (floods) and institutional issues need to be carefully considered before making investments.

In multiple-use systems

Considerable attention has been given to multiple-use systems in the basin over the last five years. The term describes the real-life water use regime of millions of rural poor and suggests that, as conditions evolve, households use multiple water sources to meet multiple water needs. If agriculture is to provide a ladder out of poverty, water is a necessary precondition:

(1) Water policy and infrastructure development for the rural poor need to favour the previously dispossessed, without diminishing the economic capacity of existing users;
(2) Since water delivered to the poor will be used to meet their needs, as prioritized by them, the burden of infrastructure costs and water pricing policies must not be borne solely by them because not all of their water use will generate income; and
(3) Given the reality of water distribution across the basin, investment in multiple-use systems should target areas where water scarcity is not going to prevent or inhibit future growth.

In the policy environment

The policy environment for natural resources management in the four basin countries has progressed over the last 15 years, but further attention is needed in the following areas:

(1) Ratification and capacity building of LIMCOM to engage in basin-scale water resources planning, as well as monitoring water use and quality;
(2) Development of a framework to secure tenure rights to land and water for rural populations in the basin, one that will encourage investment and sustainability;
(3) Pricing and prioritizing the use of water by smallholders to ensure their economic viability;
(4) Adopting a multi-sectoral approach, rather than an IWRM-alone approach. The IWRM concepts of water as an economic good and user-pays must be balanced with the concepts of the water, land and rural development sectors so as not to over-burden end users and make their economic ventures unviable;
(5) Paying specific attention to the commercial and communal sectors of the basin so that each can reach the goals set for it. For the commercial sector, the goals are regional food security, job creation and avoiding mass migration of the poor to cities. For the communal sector, the goals are rural development, poverty reduction and livelihood security, which will also help avoid mass urban migration;
(6) Coordinating efforts on the part of regional and national bodies to make their development of intervention packages a priority;
(7) Getting the necessary support to the correct recipients at the appropriate time, which takes careful planning. Institutions responsible for rural development should therefore identify those who can use agriculture as a ladder out of poverty, assess their situation, and address their specific needs. This could start with:
    (a) Mapping the communities and households in Botswana and South Africa that rely on agriculture as a primary livelihood activity so that they can be targeted for best bet intervention packages to help them climb out of poverty. The rural residents in those two countries, who have a wider range of livelihood options available to them, including social grants, may not need the agricultural interventions so badly.

(b) Mapping conditions in Mozambique and Zimbabwe so that best bet technologies, in terms of water availability, soils and livelihood systems, can be targeted at the correct audience with the necessary support systems. Smallholder agriculture is crucial to the livelihoods of the majority of rural residents in those two countries because households rely heavily on agriculture for food, income and livelihood security;

(8) Prioritizing water resources development at national level by updating approaches to determining ecological reserves, storage capacity and supply risk so that they are based on current averages. This is particularly important in the face of climate change scenarios for the region; and

(9) Directing training and technology at the actual decision makers at the household level. Policy makers and practitioners wastefully continue to underrate women's roles as decision makers and implementers in rural livelihood systems.

As we suggested above, each of the four basin countries faces essentially the same major issue: how to prioritize development and allocation of highly irregular water and contested land in the face of historical inequalities and great economic potential. The key will be for governments to design efficient and effective ways in which to reach target audiences with the most suitable technologies to improve their livelihoods. This calls for a deeper understanding of rural populations and the motivation behind their choice of livelihood activities as well as stronger and more effective institutions to help them meet their needs.

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Note

1. The SADC Revised Protocol on Shared Water Courses (2000) provides guiding principles for water sector governance within the SADC region, including the four Limpopo Basin states, all of whom have signed the protocol.

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