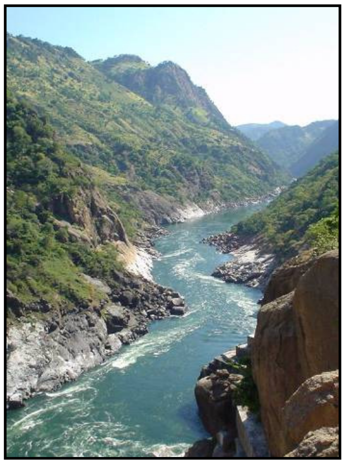
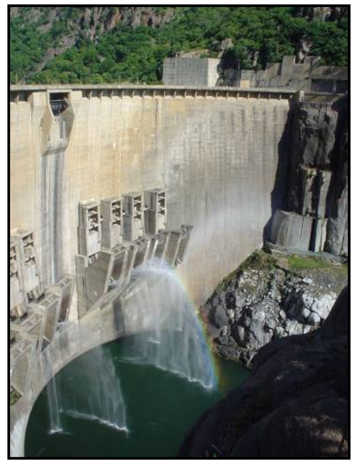
Mozambique Country Water Resources Assistance Strategy:
Making Water Work for Sustainable Growth and Poverty Reduction

August, 2007

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ABBREVIATIONS AND ACRONYMS

AAP	Africa Action Plan
ACGF	Africa Catalytic Growth Fund
AdeM	Aguas de Mozambique
AfDB	African Development Bank
CAS	Country Assistance Strategy
CEM	Country Economic Memorandum
CFAA	Country Financial Accountability Assessment
CRA	Conselho de Regulação de Água (National Regulatory Authority)
DAU	Department of Urban Water
DHS	Demographic and Health Survey
DMF	Delegated Management Framework
DNA	Direcção National de Águas (National Water Directorate)
EIB	European Investment Bank
EU	European Union
FIPAG	Fundo de Investimento e Património do Abastecimento de Água (Water Supply Invest-ment Fund)
GoM	Government of Mozambique
IAF	Inquérito aos Agregados Familiares Sobre Orçamento Familiar (Household Survey)
ICA	Investment Climate Assessment
IDA	International Development Association
IFAC	International Federation of Accountants
IRAI	IDA Resource Allocation Index
JICA	Japan International Cooperation Agency
JSAN	Joint Staff Assessment Note
LCS	Least Cost Selection
MAE	Ministério da Administracçào Estatal (Ministry of State Administration)
MCC	Millennium Challenge Corporation
MDG	Millennium Development Goal
MDRI	Multilateral Debt Relief Initiative
MOPH	Ministerio das Obras Publicaes e Habitacao (Ministry of Public Works and Housing)
NWDP	National Water Development Project
PARPA	Poverty Reduction Action Plan
PEFA	Public Expenditure and Financial Accountability
PFM	Public Finance Management
PRSC	Poverty Reduction Support Credit
PWB	Provincial Water Board
RPF	Resettlement Policy Framework
SIL	Sector Investment Loan
SWAp	Sector Wide Approach
TA	Technical Assistance
WSP	Water and Sanitation Program
WSS	Water Supply and Sanitation

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Acknowledgements

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1 Executive Summary

Mozambique's continuous efforts to sustain economic growth and reduce poverty face a number of constraints including its economic and political history, and its geography and climatic conditions. It is widely accepted that future economic growth of the country will continue to rely on its natural resources base and, specifically, on sustainable use of land and water resources. Mozambique has plentiful land and water resources that provide great potential for the production of a variety of crops, livestock development and industrial growth. However, high climate variability resulting in frequent recurrent droughts and floods, limited water resources availability in the most developed southern part of the country, high dependency on international water resources and very limited water management infrastructure result in the economy being highly vulnerable to water shocks and water being a constraint on growth and poverty reduction.

Recognizing the importance of water resources for the country's economic development and poverty reduction, water-related issues have received considerable attention in the national Second Poverty Reduction Support Strategy (PARPAII). PARPA II acknowledges the need to improve management of the country's water resources to minimize the negative impacts of climate variability, ensure the sustainability of water supply services and the availability of water for agricultural production as an important factor in achieving the development and poverty reduction goals.

The development of Mozambique Country Water Resources Assistance Strategy (CWRAS) was complementary to the Bank Country Partnership Strategy (CPS) process supporting its approach and priorities. It is consistent with the country's development priorities as defined in PARPA II and the sector priorities identified in the National Water Resources Management Strategy. The CWRAS' recommendations build upon the Bank's specific strengths vis-a-vis other development donors and, at the same time, are expected to guide the engagement of development partners and promote donor coordination and cooperation in the Mozambique's water resources sector.

The main objective of this CWRAS is to assist the Government of Mozambique in prioritizing water resources interventions based on an analysis of Mozambique's changing socio-economic circumstances, and the areas of possible Bank engagement over the next 3-5 years. Specifically, this CWRAS

(i) investigates and describes the role of water in the Mozambique economy and how the water-related vulnerability affects the country's economic performance;
(ii) analyzes water-related challenges to the country's economic development;
(iii) identifies responses to mitigate the negative and enhance the positive impacts of water on growth and poverty reduction; and
(iv) develops recommendations on priority interventions for development partners' and the World Bank's assistance in water resources development for the period 2008-2011.

Mozambique's Water Vulnerability

High dependence on shared water resources. Mozambique is a downstream riparian state on all nine of its major rivers, except the Rovuma, on which it is a parallel riparian. Over half of the country's water resources originate outside the country. The high dependence of Mozambique on shared water resources is an important factor in the national water vulnerability. In the South, all major rivers (Maputo, Umbeluzi, Inkomati, Limpopo and Save) originate in neighboring countries. Significant water abstraction from these rivers in the upstream countries, along with high flow variability, reduces water availability in these basins and increases water vulnerability of the Southern region. The management of river basins and reservoirs upstream of its territory has direct impact on its own risks, particularly related to floods.

Hydrological Variability. Highly variable climate has a significant influence on the amount, timing, and frequency of precipitation events and runoff patterns, and droughts and floods. The rainfall level varies considerably within a year with 60-80% of the annual precipitation falling in the period from December to March. The annual average rainfall ranges from over 1000 mm in Northern Mozambique to about 500 mm in the South. The inter-annual variability of rainfall is also much higher in the South than in the Northern and Center regions of Mozambique. Tropical cyclones and the El Nino/La Nina phenomenon compound the variability resulting in extreme floods and droughts such as the floods of 2000 in the South and 2001 in the Center of the country. However, floods and droughts are frequent in Mozambique, occurring cyclically with varying intensity.

High variations in rainfall, combined with limited storage facilities and underdeveloped flood control infrastructure, are main factors contributing to the **highly variable river flows** within a year, with a maximum between February and May and much lower flows in the rest of a year. In the South, the river flow is also extremely variable from year to year, with almost no flow observed in some rivers in dry years. Serious water shortages occur during dry seasons in a number of basins, especially in the South.

Water Shocks and Growth

Mozambique's economic performance is highly affected by frequent floods and droughts. The correlation between rainfall and overall GDP is strong, and sensitivity of the Mozambique economy to water shocks measured by fluctuations in GDP and growth rates of agricultural and non-agricultural sector products, demonstrates that major floods and droughts have a significant impact on the country's economic performance, reducing GDP growth on average by at least by 1.1% points annually. Given the low technological level, very limited use of irrigation and underdevelopment of water infrastructure, agricultural production in Mozambique is strongly influenced by weather conditions. The condition of extreme variability will itself affect the performance and the very structure of economies. The expectation of variability and the unpredictability of rainfall and runoff can constrain growth and diversification by encouraging risk averse behavior at all levels of the economy and by discouraging investments in land improvements, advanced technologies or agricultural inputs. An unreliable water supply is a significant disincentive for investments in industry and services, which will slow the diversification of economic activities.

Impacts on the Poor. About 10 million of Mozambique's population live in absolute poverty. Some 70% of the population relies upon subsistence agriculture for their livelihood which places the majority of the population outside of the monetary economy of the country. About one third of the population is estimated to be chronically food insecure with conditions being particularly fragile in the semi-arid Southern and Central regions of Mozambique which experience frequent droughts. Livelihood options outside agriculture are limited for the great majority of the population. The marketing network is weak and limited by extremely difficult physical access to many areas. All these factors increase vulnerability of the rural economy to the rainfall variability and related water shocks such as droughts and floods.

Water for Growth and Poverty Reduction

The Government and international aid community need to recognize the high degree of dependence of the country's economy and its social well-being on water by assigning to water resources development and management a greater priority in the national development agenda. To support growth that is also pro-poor, a careful balance must be maintained between growth and poverty reduction criteria in making investment choices. An appropriate water sector investment strategy is a blend of all these types of interventions, operating on the resource and on water services, intervening in a broad, systemic manner as well as directly targeting the poor.

The CWRAS identifies the following priority areas of investment which will require financing from a range of sources including the Government, the development partners (including the World Bank) and the private sector.

A. Water resources development and management in the Incomati and Umbeluzi basins.

Investments in the next least-cost incremental augmentation of bulk water sources for Maputo which is required by 2012 to avoid shortages. There are a number of options for this of which the apparent least-cost option is the completion of the Corumana dam and construction of a water treatment plant and main transmission pipeline for water supply to Maputo. In time the construction of the Moamba Major reservoir will also be required to serve the needs of the Greater Maputo Area - Refer to the World Bank July 2007 study entitled "Preliminary Economic Analysis of Maputo Bulk Water Source Development";

(i) Construction of a dam and reservoir, a small treatment plant and a distribution system for the town of Ressano Garcia;
(ii) Support to further strengthening of the Inco-Maputo and Umbeluzi basins agreements between Mozambique, South Africa and Swaziland for sharing the water shortages during droughts and the joint implementation of flood warning systems;
(iii) Pilot initiatives to test new approaches in the management of irrigation schemes with farmer-led management of irrigation water delivery systems; and
(iv) Support to institutional strengthening of ARA-Sul, including introduction of a new tariff system for water users to ensure the sustainability of operation and maintenance of the water resources infrastructure.

B. Small scale water resources development.
(i) Construction of small and medium multi-purpose dams for Nampula, Nacala and Quelimane in the Northern Mozambique;
(ii) Community-based sustainable management and development of water resources of small streams, groundwater resources, and local watersheds in the poorest areas (for example, in Nampula Province);
(iii) Support to smallholder irrigation. Principles for selecting provinces or regions to commence such a program include
  a. Preference for areas which have the largest numbers and concentrations of poor smallholder farming families,
  b. The presence of a network of rivers and streams that provide sites with access to water and suitable soils and topography for smallholder irrigation;
  c. Proximity to long term opportunities for larger irrigation schemes that will include smallholders, so that an "irrigation culture" evolves to make possible further steps towards the long term irrigation vision;
(iv) Water infrastructure for small towns.

C. Water resources development and management in the Zambezi basin. This, specifically, includes:
(i) Assistance for provision and implementation of the environmental requirements of the Mphanda Nkuwa and Cahora Bassa North water resources developments;
(ii) Analysis of Zambezi basin multi-sector investment opportunities. The study would provide the analytical foundations to both assist the Bank in defining a long-term support strategy for investments within the basin and riparian countries, and contribute to the processes being undertaken by the riparian states of the Zambezi Basin.

D. Support in Water Supply and Sanitation. Support to institutional development and capacity building, including: financing the management contracts for Beira, Quelimane, Nampula and Pemba.

E. Policy development in the water sectors. The principal objective of this assistance would be to support GoM in further development of an appropriate set of policies and instruments to strengthen water resources planning and development in the country and to improve co-ordination of the water user agencies within the framework of integrated water resources management.

F. Institutional building in the water sector. The assistance to be provided to GoM in strengthening the water sector institutions would improve efficiency of the sector institutions (DNA and ARAs) and promote stakeholder involvement in water resources management at the national, regional and local levels.

G. Risk Reduction and Disaster Management. The objectives of this technical assistance to the Government of Mozambique are to:
(i) Mainstream disaster risk reduction in strategic planning and sectoral development policies;
(ii) Support the government to develop its institutional and human capacity to manage disaster risk,
(iii) Provide specific support to strategic activities to enhance preparedness at national and district level; and
(iv) Facilitate the best application of World Bank Group experience and knowledge to disaster risk management for the short and long term within the context of country economic analysis and sectoral growth strategies.

2 Introduction

2.1 Background to Mozambique Country Water Resources Strategy

This document has been prepared after an extensive process of consultation and discussion in Mozambique including the holding of a public workshop in Maputo in September 2006 on the initial findings of the study. It follows the preparation of an initial scoping document entitled "**The Role of Water in the Mozambique Economy –** *Identifying Vulnerability and Constraints to Growth"*, June 2006. Water is an essential requirement for many growth and poverty reduction related activities which has resulted in the need for input into the preparation this document from a range of different sectors.

The World Bank has undertaken 18 Country Water Resources Assistance Strategies to date. These have variously addressed different issues and aspects of water resources management and development to meet the specific challenges and development context of the respective countries. As the first CWRAS for Mozambique, this document provides an important foundation for supporting the Government of Mozambique's commitment to growth and poverty alleviation. The CWRAS for Mozambique presents a clear sectoral strategy that is aligned with the Government's strategy in the water sector. This document has been prepared as a rolling 5-yr strategic process that inputs to the broader Country Partnership Strategy.

2.2 Development Context

Mozambique has made significant socio-economic progress since the peace agreement in 1992. Increased political stability, the introduction of a multiparty democracy, deep economic reforms along with strong external financial and technical support have all contributed to the transformation of Mozambique's economy. Real GDP has averaged 8.1% since 1993 and is well above the African average. Performance has been most vigorous in industry and fisheries, construction and services with agricultural growth playing an important role. Poverty rates have fallen from 69.4% in 1997 to 54.1% in 2003, with a 16% reduction of poverty in rural areas. This has significantly reduced the rural-urban gap, from 9.3% in 1997 to 3.8% in 2003.

Mozambique is one of very few examples in Sub-Saharan Africa to show a combination of high growth and a significant reduction in both overall and rural poverty.

Despite these achievements, Mozambique remains one of the poorest countries in the world. Per capita income is US$340 in 2006 and below the average for other sub-Saharan Africa (US$745) and low income (US$580) countries. Subsistence agriculture continues to employ the vast majority of the country's workforce. The achievements in poverty reduction also mask significant regional variations, a slight increase in income inequality since 1997, and persistent, high levels of absolute poverty and malnutrition. Key social indicators for Mozambique continue to be below the averages for other Sub-Saharan African and low-income countries. Reflecting this, the UN Human Development Index (an index of income, education and life expectancy) ranks Mozambique 170 out of 173 countries. Thus, the main development challenge facing the Government of Mozambique (GoM) is sustaining high economic growth while reducing the levels of absolute poverty. The Government's strategy for addressing development and poverty over the medium term are set out in the "National Action Plan for the Reduction of Absolute Poverty (Plano de Acção para a Redução da Pobreza Absoluta: PARPA)".

The public action strategy elaborated in PARPA II identifies a number of development challenges, emphasizing widespread rural poverty, unequal development and regional disparities, the growing threat of HIV/AIDS and the high vulnerability to natural disasters. Several priority areas are identified for implementation, including education, health, basic infrastructures (energy, water supply and sanitation and water management), agricultural and rural development, good governance, and sound macroeconomic and financial management.

PARPA II specifically acknowledges the importance of water-related issues to the country's economic development and poverty reduction. Proposed priority actions in the water sector include increasing the coverage of water supply to 70% of residents in urban, as well as rural, areas by 2015, and sanitation services to 80% of the urban and 50% of the rural population by 2015. PARPA II also recognizes the importance of water resources management (WRM), its role in minimizing the negative impacts of climate variability and in achieving development and poverty reduction goals. Specific reference is made to the importance of WRM in relation to such priority development areas as rural development, water supply and sanitation, natural disaster management, food security and nutrition, and the environment. The development of water resources is also acknowledged as an important factor in increasing Mozambique's electricity production capacity.

The main objectives of the WRM sector are defined by the PARPA II as mitigating and managing the threat of extreme events (floods and droughts); ensuring the sustainability of water supply and sanitation services; ensuring the availability of water for agricultural production and rural development; and sustaining the ecological balance of aquatic systems[i]. The priority program outlined by PARPA II in the area of WRM includes "construction of excavated reservoirs; rainwater collection systems; and small, medium, and large dams in order to satisfy the needs for water for human consumption, livestock, irrigation, fisheries, industry, tourism, electricity production—among other uses—to mitigate, in a planned manner, the negative effects of droughts and floods, with a view to ensuring sustainable management of the country's water resources"[ii].

2.3 The World Bank Country Water Resources Assistance Strategy

2.3.1 The Country Assistance Strategy

The World Bank Country Assistance Strategy (CAS) for financial years 2004-2007 (FY04-07) outlined a program of support to the GoM to assist its efforts in achieving poverty reduction and economic growth goals. The Bank has supported efforts aimed at improving the investment climate, expanding service delivery and building public-sector capacity and accountability structures. The focus on poverty alleviation focus was maintained through full-service policy advice and complementary instruments to support the private sector, along with selected interventions in rural development, education, health, agricultural services, infrastructure and governance. Support to the water sector was addressed through support to the National Water Development Project II (NDWPII). NDWPII supported private-sector urban water supply and development of the National Water Resources Management Strategy (NWRMS).

The World Bank's Country Partnership Strategy (CPS) for 2008-2011 has been developed to promote growth and pro-poor service delivery within the context of PARPA II. Results are expected to build on those of PARPA I, through deepening efforts and support to second-stage reforms while addressing gaps identified through the implementation of PARPA I. PARPA II also adds focus on key cross-cutting objectives that require coordination across key sectors to be addressed effectively. The Bank's FY08-11 CPS is timed to be in sequence with the development of the GoM's strategy, to accommodate the lag between the finalization of PARPA II, the coordination effort among the donors to develop a joint analysis, and the development of donor strategies.

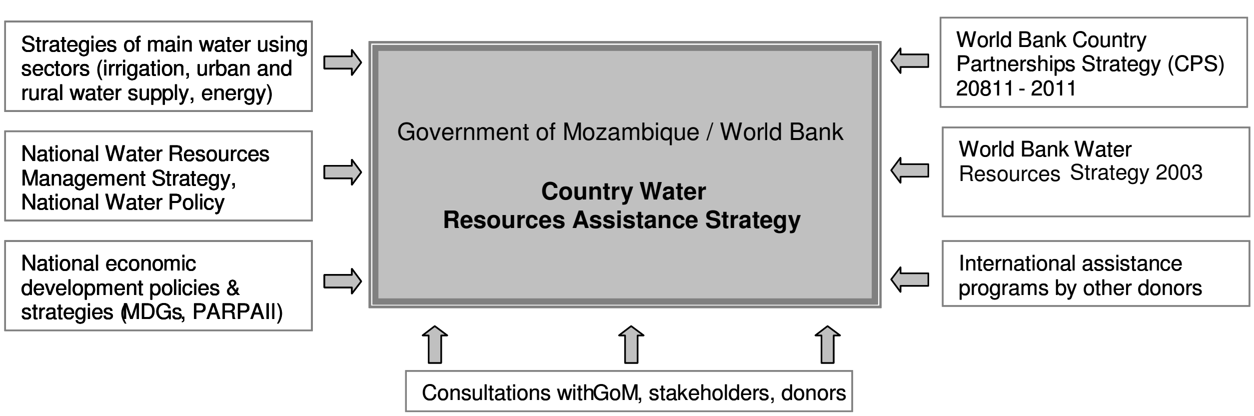


Figure 1.1. Development of Country Water Resources Assistance Strategy.

2.3.2 Objectives of this CWRAS

The World Bank has been involved in the water sector in Mozambique since 1998. Development of the Country Water Resources Assistance Strategy (CWRAS) is complementary to that of the CPS and is intended to be consistent with the country's development priorities, as defined in PARPA II, and sectoral priorities identified in the NWRMS (Figure 1.1). Note that the CWRAS differs from the National Water Resources Management Strategy in a number of key ways. The NWRMS identifies a large number of potential and important development and management needs but does not apply an economic analysis or prioritization to these. The NWRMS also does not indicate where the Bank specifically should provide assistance.

The aim of the CWRAS is to support the GoM in prioritizing water resources interventions and the Bank's support over the next three to five years. In order to have the most impact on long-term poverty reduction and economic growth, the Bank's continued assistance in the water sector is to be tailored to Mozambique's changing socio-economic circumstances, within the context of the approach and priorities outlined in the FY08-11 CPS. The CWRAS is used to identify the Bank's specific strengths *vis-a-vis* other development partners and, at the same time, promote donor coordination and cooperation in the water resources sector in the identified priority areas of interventions.

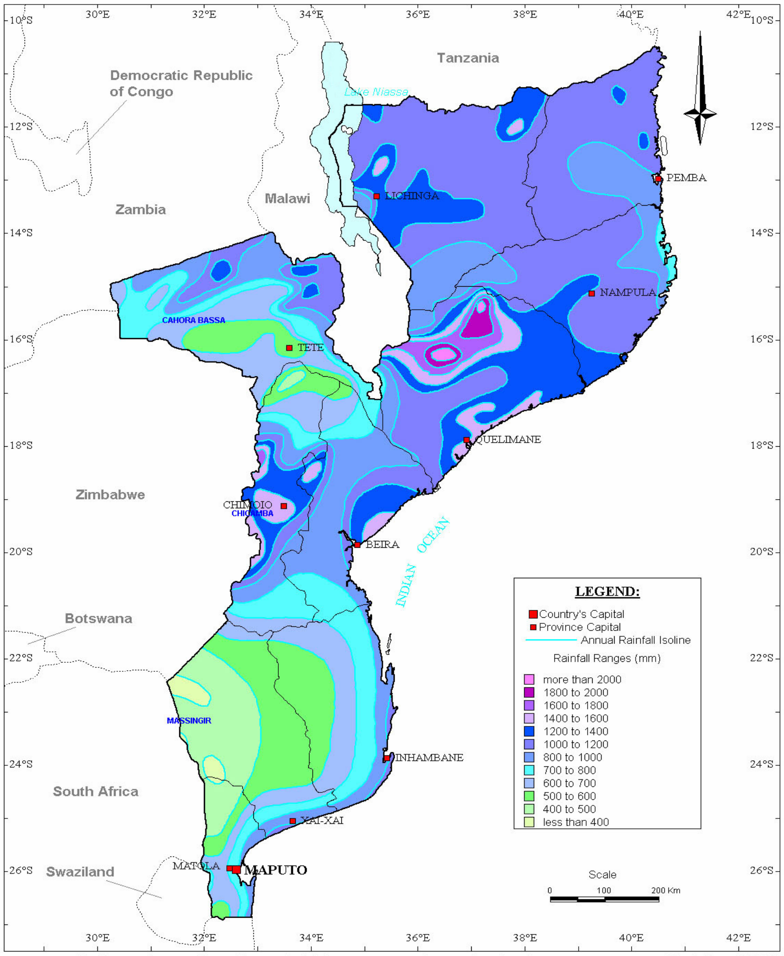
Specifically, the objectives of this CWRAS are to:

(i) describe the role of water in the Mozambican economy and how water-related vulnerability impacts economic performance;
(ii) analyze water-related challenges to the country's economic development and identify main areas for interventions to mitigate the negative, and enhance the positive, impacts of water on growth and poverty reduction; and,
(iii) develop recommendations on priority interventions for the Bank's assistance in the water resources sector for the period 2008-2011, underpinned with an analysis of financing and implementation instruments, and donor partnership.

The main methodological principles for developing the CWRAS are defined by the World Bank's 2003 Water Resources Sector Strategy (Box 1.1). The CWRAS is structured as follows: Sections I and II describe the impacts of hydrological variability on economic performance and analyzes water–related challenges to Mozambique's economic development. Section III defines the framework for outlining priority water development responses to these challenges, starting with an analysis of key strategic issues in the main water using sectors and how they relate to water resource management. Finally, Section IV outlines a strategy for the Bank's assistance between 2008 and 2011 to support Mozambique in making water resources work for sustainable economic growth and poverty reduction.

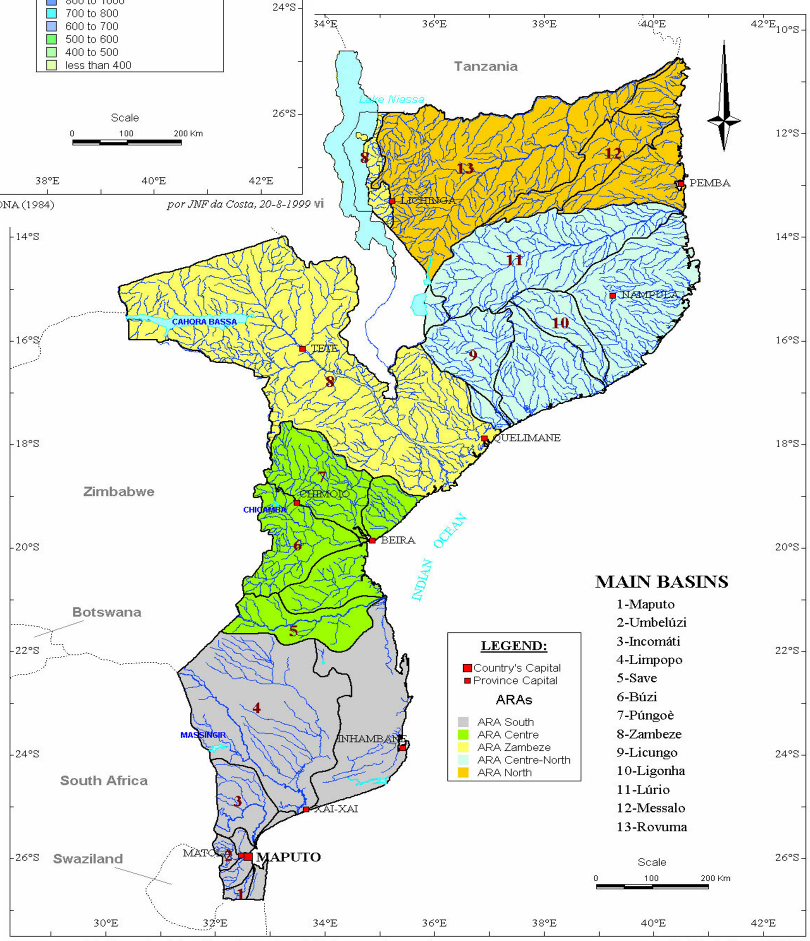
Map 1. Map of Mozambique

Map 2. Annual Rainfall Ranges in Mozambique

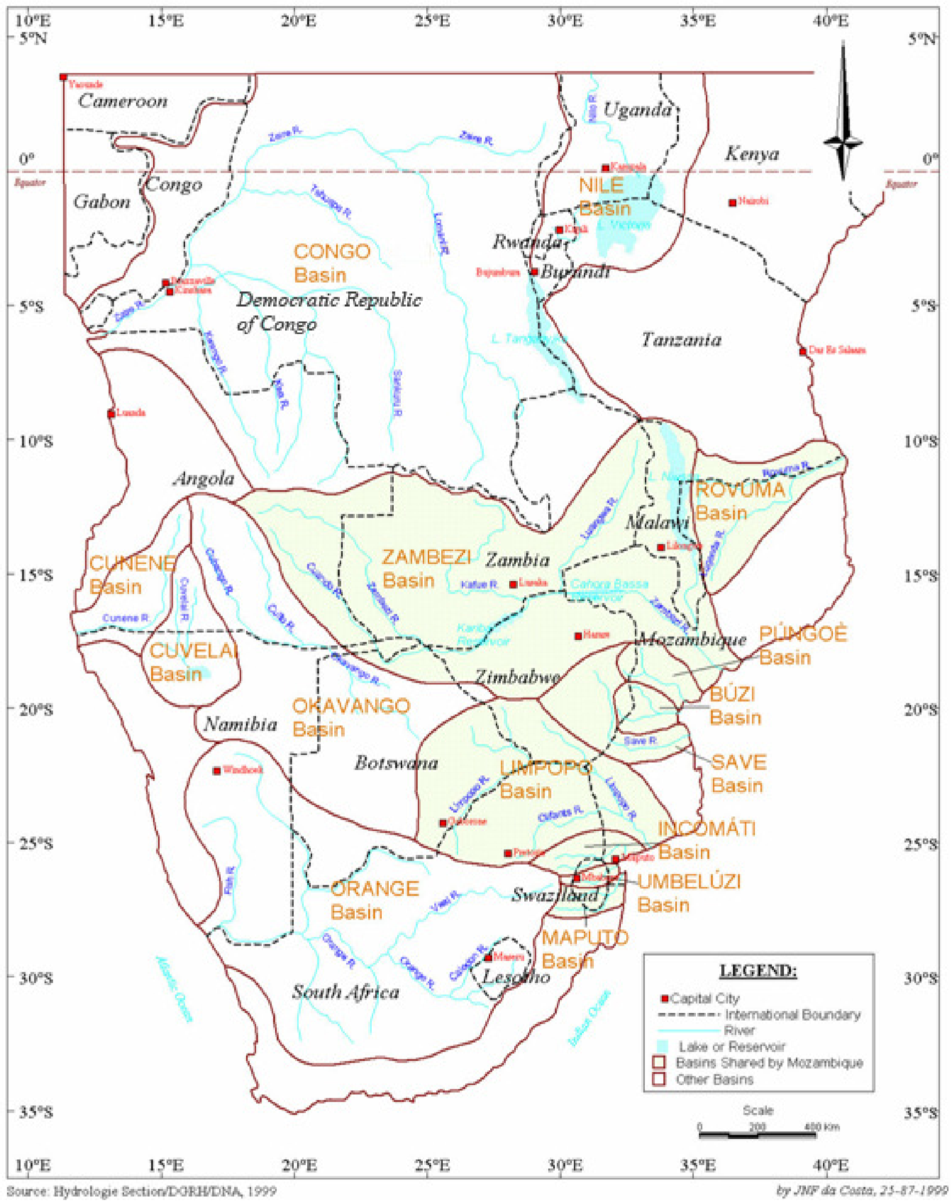


Sources: Map with title "Mapa de Moçambique, Divisão Territorial" (by DINAGECA, 1987), DGRH/DNA (1984) and Geographical Atlas of Mozambique (Atlas Geográfico,1986).

Map 3. Main River Basins of Mozambique



Sources: Map with title "Bacias Hidrográficas" (by Serviços Hidráulicos, 1976), DGRH/DNA, 1998 *by JNF da Costa, 20-8-1999*



Map 4. Mozambique International River Basins

3 Water related Challenges to Mozambique's Economic Development

Water is instrumental in the performance of a number of economic sectors in Mozambique. These include the agricultural, health, industrial and commercial sectors, as well supporting important natural resource-based livelihoods among rural communities and the poor. Strong economic growth in agriculture is the most important factor driving poverty reduction. Therefore, over the next 5-10 years agricultural growth will remain a priority for the GoM and international assistance. Inadequate water supply and sanitation services have a particularly adverse effect on the health of the poor, and accordingly on their ability to contribute to the country's economic development. Growing and competing water demands from the major sectors of the economy, and specifically, agriculture, may also impose a serious constraint on the medium- and long-term growth prospects in terms of water availability in some river basins. Extreme hydrological and climatic variability present serious risks associated with frequent floods and droughts that constrain the actual output growth. Supporting this is growing evidence of a negative correlation between rainfall variability, real total GDP and agricultural GDP growth.

3.1 Mozambique's Water Vulnerability

Mozambique is not considered as water scarce. It is, however, highly water vulnerable and insecure because of increasing uncertainty in the national water resources base. This is due to the high dependency on international river basins (over half of the national water resources are shared with neighboring countries), variable climate with high variations in annual and inter-annual rainfall, frequent flood and drought events, the uneven geographic distribution of water resources across the country and competing future demands by water-dependent economic sectors in many river basins. These contributing factors are aggravated by an underdeveloped and largely degraded stock of water infrastructure that increases water vulnerability and poses a serious risk on the national economy.

Mozambique's Water Resources. Mozambique has 104 main river basins, of which 50 have catchment areas less than 1,000 km^2, 40 have areas between 1,000 and 10,000km^2, 12 between 10,000 and 100,000

Box 2.1. Main International River Basins

- The **Maputo basin**, shared with South Africa and Swaziland, is rich in biodiversity supporting a number of key protected areas and at risk from upstream developments.
- The **Umbeluzi basin**, shared with South Africa and Swaziland, is the primary water supply for Maputo and supports extensive irrigation in Swaziland smallholder agricultural schemes in Mozambique.
- The **Buzi basin**, shared with Zimbabwe, includes the Chicamba Dam on a tributary, the Revuè River, which provides water for agriculture and domestic supply.
- The **Incomati basin**, shared with South Africa and Swaziland, is heavily exploited, primarily for irrigated agriculture in South Africa, which has resulted in significant flow reductions in the last 15 years.
- The **Limpopo basin**, shared with South Africa, Botswana and Swaziland, supports Mozambique's largest irrigation scheme, Chokwe. Intensive water-use upstream, particularly in Zimbabwe and South Africa, has resulted in water quality problems and reduced flows into Mozambique such that the river is dry for 3-4 months in a normal year, and can actually remain dry for a period of up to 8 months in a year.
- The **Save basin**, shared with Zimbabwe, has at least 17 major dams throughout the basin and is now dry almost on a permanent basis due to an intensive program of water resources development in Zimbabwe during the 1980s.
- The **Pungue basin**, shared with Zimbabwe, includes the Gorongosa National Park and is an important source of supply for Beira, supporting agriculture, fisheries and aquaculture and experiences saltwater intrusion up to 80km inland due to reduced flows.
- The **Zambezi basin,** shared with Angola, Namibia, Botswana, Zimbabwe, Zambia, Malawi and Tanzania, **covers 4.5% of the African continent and plays an important role in energy production, agriculture, fisheries, tourism and conservation**.
- The **Rovuma basin,** shared with Tanzania, is largely undeveloped, providing important wilderness areas and natural services.

km^2, with the Zambezi River and Rovuma River having catchment areas more than 100,000 km^2. The most important river basins, from south to north, are the: Maputo, Umbeluzi, Incomati, Limpopo, Save, Buzi, Pungoe, Zambezi, Licungo, Lurio, Messalo and Rovuma (Map 3). With the exception of the Licungo, Lurio and Messalo, all other basins are shared with at least one other country. The Zambezi River basin is shared by a total of eight countries.

The water resources situation in Mozambique, in absolute terms, compares reasonably well with other countries occupying similar climatic zones. Total mean annual runoff is estimated at 216 km^3/year. The total inflow at the border is about 116 km^3/year while the runoff generated within the country averages about 100 km^3/year. Therefore, more than 50% of the total mean annual runoff is generated outside of the country. The Zambezi basin represents about 18% of the country's total mean annual runoff and 75% of the total cross-border inflow: the basin receives 88 km^3/year of inflow at the border and 18 km^3/year of the basin's runoff is generated within the country, giving a total mean annual runoff of 106 km^3/year. The availability per capita of surface water resources is about 5550 m^3/year (only for the runoff generated within the country) or 12000 m^3/year (including the cross-border flows).

Mozambique is a downstream riparian state on all nine of its major rivers, except the Rovuma, on which it is a parallel riparian. The ***high dependence of Mozambique on shared water resources*** is an important factor in the national water vulnerability (Map 4). All of the major rivers in the southern part of Mozambique (Maputo, Umbeluzi, Inkomati, Limpopo and Save) originate in neighboring countries. The naturally high levels of flow variability, necessitating high storage capacity, along with significant abstraction from these rivers in the upstream countries reduces water availability and increases water vulnerability in Mozambique's southern region. The combined average natural flow in the four basins[iii] is about 11 km^3/year. This is predicted to decrease to about 5 to 6 km^3/year over the next 20 years, with increasing variability due to growing demands from riparian neighbors. The management of river basins and reservoirs upstream of its territory has direct impact on its own risks, particularly

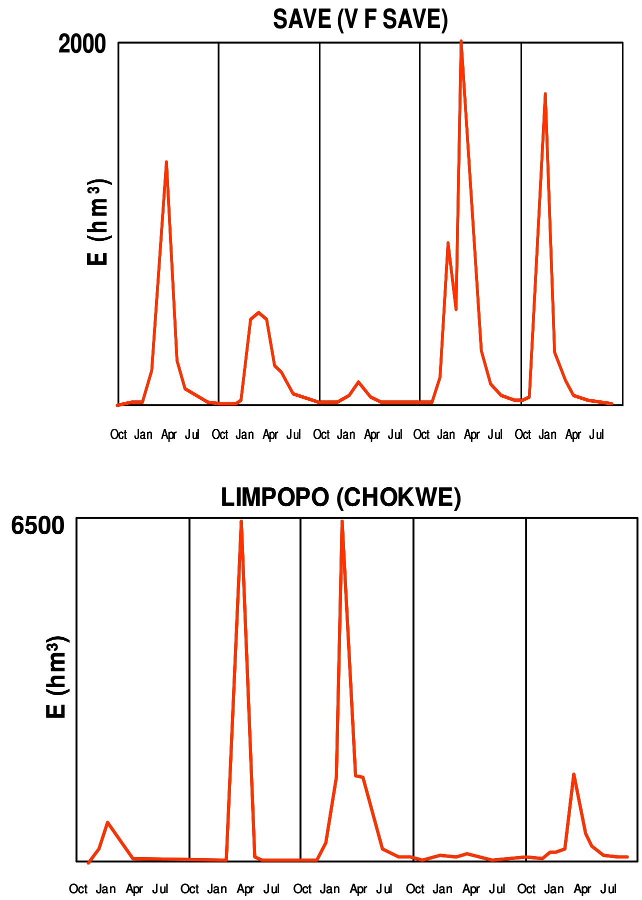


Figure 2.1. Monthly flows in Save and Limpopo rivers in 1965-70 hydrological period

related to floods. To mitigate these risks, Mozambique is very active in a number of joint processes with riparian countries to ensure that its interests and concerns are addressed.

Hydrological and climatic Variability has a significant influence on the amount, timing, and frequency of precipitation events, runoff patterns, and the cycle of floods and droughts. The levels of intra-annual rainfall vary considerably, with 60-80% of the annual precipitation falling between December and March. The annual average rainfall ranges from over 1000mm in northern Mozambique to about 500mm in the southern region. The southern region of Mozambique also experiences a much higher degree of inter-annual rainfall variability than in the northern and central regions (Map 2).

Tropical cyclones and the El Nino/La Nina phenomenon compound the hydro-climatic variability contributing to extreme ***floods and droughts***, such as the floods of 2000 in the south and 2001 in the center of the country. However, frequent floods and droughts occur cyclically in Mozambique with varying intensity. More localized droughts are observed every three to four years, although are often not well recorded. According to the National Meteorology Institute (INAM), the intervals between extreme rainfall events are shortening, while the intensity of these rainfall events is increasing. Over the last 25 years Mozambique has experience major floods in 1977-1978, 1985, 1988, 2000, 2001 and 2007, and major droughts in 1981-1984, 1991-1992, 1994-1995, 2002-2003. It is predicted that these conditions will be exacerbated by climate change[iv].

High variations in rainfall, combined with limited storage facilities and under-developed flood control infrastructure are the main factors contributing to the ***highly variable inter-annual river flows***. Discharge peaks between February and May with typically much lower flows during the rest of the year. Serious water shortages occur during dry seasons in a number of basins, with minimum monthly flows as little as 1 to 2% of the annual runoff for many rivers. In the southern part of Mozambique, river flow extremes from year to year are often result in the absence of flow in some rivers during dry years. This means that the amount of usable and available water resources depends heavily on the development of storage and diversion infrastructure. Without large and small scale water storage infrastructure, only a fraction of total runoff can be utilized to meet the demands.

3.2 Impacts of Hydrological Variability on Economic Performance and Poverty Reduction

Water Shocks and Growth. Mozambique's economic performance is significantly affected by the frequency of floods and droughts. There is a negative correlation between rainfall and overall GDP, and sensitivity of the Mozambique economy to water shocks measured by fluctuations in GDP and growth rates of agricultural and non-agricultural sector products demonstrates that major floods and droughts have a significant impact on the country's economic performance (Figure 2.2).

A regression analysis undertaken in a World Bank study[v] over the period 1981-2004, suggests that GDP growth in Mozambique is cut by 5.6% points, on average, when a major water shock occurs. Assuming the rate of the major disaster occurrence is, on average, one in every five years, then GDP growth in Mozambique is reduced by 1.1% points annually due to the impacts of water shocks. The total costs of water shocks in the period 1980-2003 are estimated at about US$1.75 billion[vi]. [See also Endnote xxviii and Appendix B - *World Bank Memorandum: "The Role of Water in the Mozambique Economy*".]

The condition of extreme variability will itself affect the performance and the very structure of economies. The expectation of variability and the unpredictability of rainfall and runoff can constrain opportunities for growth and diversification by encouraging risk averse behavior at all levels of the economy in all years. Under such conditions economic actors, particularly the

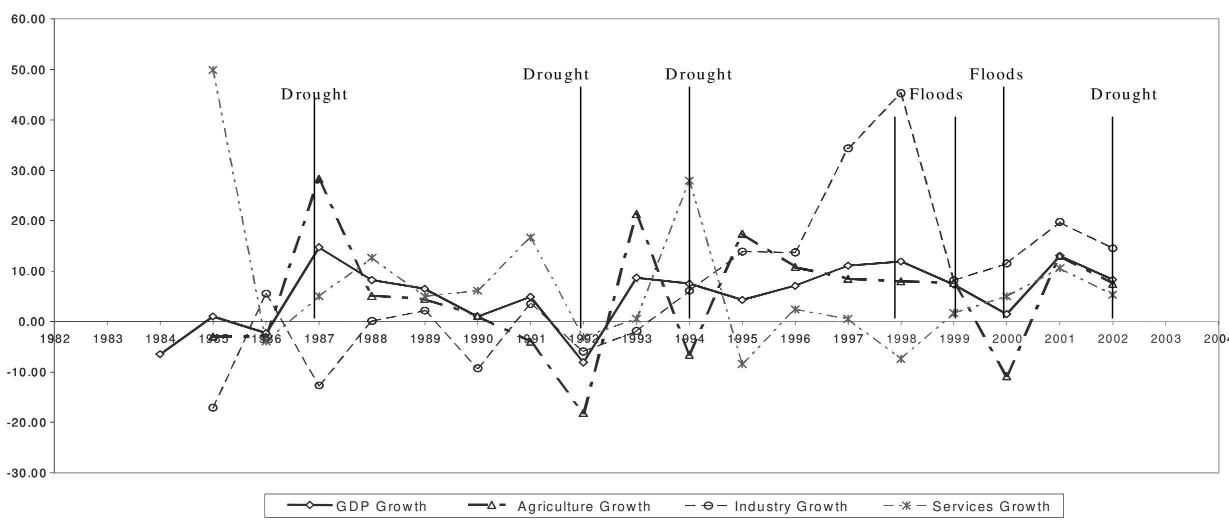


Figure 2.2. Mozambique: Real GDP Growth Rates and Rainfall (1988-2002)

poor, focus on minimizing their downside risks, rather than maximizing their potential gains. It discourages investments in land improvements, advanced technologies or agricultural inputs. These in turn constrain agricultural output and productivity gains. An unreliable water supply is a significant disincentive for investments in industry and services, slowing the diversification of economic activities. This risk averse behavior has a structural impact, promoting patterns of development that can trap economies in low-level equilibriums.

Impacts on the Poor. About 10 million Mozambicans live in absolute poverty. Some 70% of the population relies upon subsistence agriculture for their livelihood which places the majority of the population outside of the monetary economy of the country. The costs to this segment of the population of recurrent water related shocks and underdevelopment remain therefore largely unrecorded and outside of the reckoning of costs of these events at national level.

The chronically food insecure are estimated to be about one third of the total population. An additional 20 to 25% of the country's total population is considered highly vulnerable to transitory food insecurity. Production of cereals, and especially, maize as the main food staple for the majority of rural and lower income urban population, is central to food security in Mozambique. While cereal production was growing in the north and the centre of the country over the last 10 years, food security conditions continued being fragile in water-insecure districts located mainly in the semi-arid regions of the Southern and Central regions of Mozambique with high probability of droughts.

Livelihood options outside agriculture are limited for the great majority of the population. The marketing network is weak and limited by extremely difficult physical access to many areas. All these factors increase vulnerability of the rural economy to the rainfall variability and related water shocks such as droughts and floods. Rural households are particularly susceptible to droughts due to the self-provisioning nature of the farming and weak marketing infrastructure. Home consumption accounts for 65% of total agricultural production valued at producer prices and represents about 23% of total household consumption of commodities[vii]. A large part of home-consumed production is due to safety-first considerations because of high expectations of food security problems accompanying frequent droughts and floods.

3.3 Unexploited Irrigation Potential

Mozambique is still largely a rural society with over 80% of the total labor force involved in agriculture and very limited employment opportunities in non-farm sectors. About 45% of the country is considered suitable for agriculture. However, only 4 % of the total arable land is presently cultivated. Almost 95% of the cultivated land in Mozambique is cultivated by the family sector. In 2005 the agricultural sector's share in total GDP was 23%, and about 70% of the population lives in rural areas. The sector grew at a 6% average annual rate from 1992 to 1996, and 6.6% between 1996 and 2004 (IMF, 2005).

Mozambique's poverty is closely linked to its dependence on rain-fed subsistence farming in the context of highly variable rainfall and frequent droughts. Within the framework of increasing agricultural output and reducing poverty, the PARPA and PROAGRI emphasize the need to increase agricultural productivity, improve access to land and secure land tenure, and facilitate rural trade. Irrigation is considered an important factor in increasing agricultural productivity and food security for the poorest part of the population. Irrigation helps to diversify income and reduce rainfall – related risk. However, despite the prominent attention given in policy documents such as PARPA to food security and water availability for agricultural development, the growth of irrigation in Mozambique is very slow.

The country has considerable untapped opportunities for irrigation, with only 4% of a potential 2.7 million hectares developed for irrigation. Irrigation in Mozambique can be categorized into three types; the large-scale irrigation schemes such as in the Limpopo Valley and the private sugar companies; medium-scale irrigation, generally covering less than 50 ha; and small scale and micro irrigation, often based on treadle pumps and other manual methods. The incidence of irrigation is substantial among commercial farms (over 30%), but low among smallholders. Surveys indicate that the proportion of farmers using some irrigation rose from about 3% in 1996, to 11% in 2002, but these figures are regarded as unreliable and appear to be too high.

The Government intends to increase the current effective irrigated area in the medium term, which would be mainly achieved through rehabilitation of the existing irrigation schemes (which are currently not in use), using public and private funding. In addition to improving management of existing irrigation infrastructure, new irrigation systems for smallholders, including small dams and groundwater development, would mitigate vulnerability from unpredictable rainfall.

3.4 The Need in Hydropower

Hydropower generation is one of the most important non-consumptive water users in Mozambique. Mozambique has one of the lowest electrification rates in Southern Africa (approximately 5%). However, the gross national electricity consumption has increased substantially as several mega projects have been implemented. The construction of a new aluminum smelter, Mozal, has increased the national energy consumption three fold since 2002. However, the domestic electricity consumption still remains very low at 78kWh per capita (in South Africa it is 3,745kWh per capita).

Electricity is the most serious infrastructure problem for the Mozambican manufacturing sector, with nearly 64% of firms ranking it as a major or severe problem. Power outages and oscillation of the voltage has led to the loss of equipment. As capacity utilization increases, and firms begin to engage in continuous production, an erratic power supply will become an ever-increasing constraint. The *Investment Climate Assessment* (World Bank, 2003) reported that firms suffered 17.5 power outages per month, or on 193 days in the year, well above the nine African countries surveyed whose average was 77 days. Outside Maputo it is more acute: in the Center and the North, average monthly power outages were 30 and 29, respectively. Only 220,000 households (some 6% of all households) had access to electricity in 2004.

80% of the current energy production in Mozambique comes from the Cahora Bassa hydropower plant (HCB) with an installed capacity of 2075MW, most of which is exported. One option for EDM in the coming years is to meet growth in domestic demand from additional power allocation from the HCB utilizing un-exported surpluses. An agreement has been reached between Mozambique and Portugal regarding the transfer of majority ownership of HCB to Mozambique, but the additional developments of a power plant on the north bank of Cahora Bassa and the Mphanda Ncua dam remain uncertain.

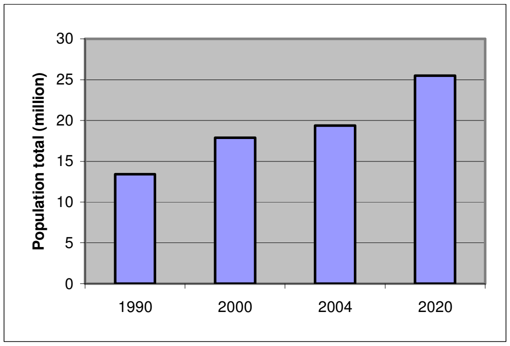
Potential hydropower generation in Mozambique is substantial. According to EDM, about 13000 MW, producing 65000 GWh/y of energy, can be economically developed in Mozambique. About 70% of this potential (10000 MW, 45000 GWh/y) is concentrated in the Zambezi watershed, most of it on the Zambezi river. There is an attractive market now for power from Cahora Bassa and other possible power plants on the Zambezi. These new power schemes can also be used to structure the future Mozambique national grid that would allow power sharing between several production centers and create conditions for incorporation of smaller power production schemes on other center and northern river basins**.**

3.5 Urbanization and Water Supply

While the population of Mozambique is expected to grow at the moderate annual rate of 2.2-2.3% between 2005 and 2020[viii], rural-urban migration is expected to continue. The urban population may possibly grow as much as 4-5% per annum. Currently, 70 % of the total population live in rural areas where 55% remain poor. In urban areas an unusually high proportion, 51%, is poor reflecting a steady trend in migration of the rural poor into the cities.

At present, more than 70% of the rural population and about 30% of the urban population[ix] do not have access to an adequate water supply[x]. Currently, the production capacity of water supply systems for the 13 main cities, with a total about 4 million inhabitants, is about 250,000 m^3/day (or a total production of about 80 Mm^3/year). About 75% of this production is serving the Maputo area, (mainly from the Umbeluzi river, regulated by the Pequenos Libombos dam)[xi]. Most of the urban water supply relies on provision of surface water. Only four main cities – Pemba, Tete, Xai-Xai, and Chokwe – rely on groundwater supply.

The provision of safe and reliable domestic water supply to the urban and rural population is one of the Government's main development priorities. It is estimated that urban drinking water demand, with increased per capita availability, reduced losses, projected increase in the urban population and increased coverage in the service, may reach about 250 m^3/year in total by 2015[xii].



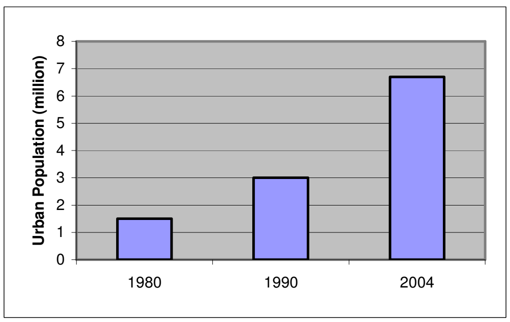
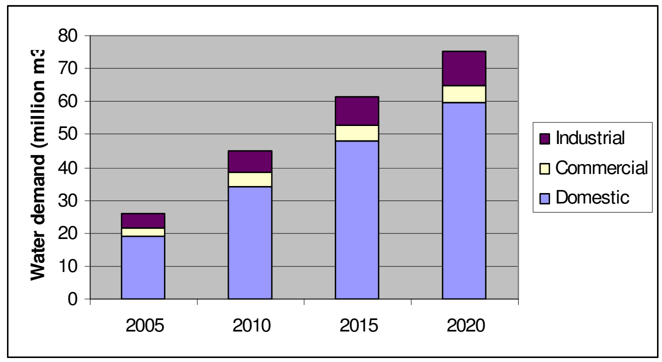


Figure 2.3. Growth of total and urban population in Mozambique

Mozambican industries are concentrated in the country's major cities – Maputo, Matola, Beira and Nampula, and their water supply almost exclusively relies on the existing urban water supply systems. No accurate information is available on water consumption by industries. However as the country pursues its industrialization policy, it is expected that there will be increased demand for water to meet the production requirements. For Maputo the current consumption is estimated in the order of 10,000m3/day (Figure 2.4).

It is expected that this water consumption will double with construction of new planned industries such as Mozal 3 and the MISP (Maputo Iron and Steel factory). Currently, Mozal uses 50,000 m3 of water per month and has requested a guaranteed supply of 75,000 m3/month in the future to meet the needs of the extended Mozal 3 project.

In most cases, the water production increase can be obtained from small local intakes or reservoirs. However, in case of Maputo and Beira, the increase in water supply is likely to require larger scale infrastructure solutions on the Incomati river (for Maputo water supply), and, in the case of water supply to Beira, on the Pungue river, which would also provide water for the expansion of irrigated agriculture.



Data Source: Communication with FIPAG

Figure 2.4. Maputo water demand projections

3.6 Inadequate Coverage of Water Supply and Sanitation of Small Towns and Rural Areas

Mozambique is close to the African average for most social indicators except access to water, which, at 37%, falls far short of the average of 58%. This is mainly because rural water access is low, at 27%, compared to the African average of 46.5%[xiii]. In Mozambique overall spending on water supply for cities and large towns has historically exceeded that on small towns and rural areas due to the low investment absorption capacity of the rural WSS institutions. As a result, the rural population (including small towns) which constitutes 73% of the total population, has a water supply coverage of 27%, while the coverage in the urban areas is 65%. In 2003-2004 Government spending (own revenues and donors' contributions) on expanding water access per head of un-served population, was six times greater for urban areas than for rural. (This needs to be viewed in the light of higher costs and higher levels of service in urban areas where services such as wells and hand pumps are not possible.) PARPAII defines the targets for improvement in rural water supply and sanitation as "increasing coverage of rural sanitation services to 40%, serving 6 million people in rural areas by 2009, and achieve 50% in 2015, serving 8.4 million people"[xiv].

3.7 Conflicts between Growing Water Demand and Water Availability

Mozambique has a US$4.3 billion economy. While the share of agriculture in GDP was falling steadily, it still produces approximately 22% of the GDP, industry (including manufacturing) produces about 33%, and services produce about 45% of the GDP (Figure 2.5).

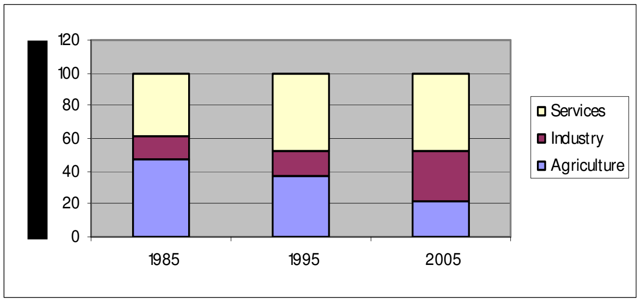


Figure 2.5. Contribution to GDP by Sector

All these sectors are highly dependent on an adequate supply of water. Agriculture (including irrigation, livestock and forestry) uses about 73% of the total water consumption, with industries using about 2% (Table 2.1). Urban and rural domestic water supply uses most of the remainder (about 25% of the total water consumption) and has an important direct impact on public health.

Most of the sectors which contribute to the Mozambican economy are either directly dependent upon secure, sustainable water availability or are indirectly affected by water shocks (droughts or floods). The growing water demand from the major sectors of the economy, specifically agriculture, impose a serious constraint on the medium-term and long-term growth prospects in terms of water availability in some river basins, especially in the economically most developed South and the Center. From 2003 to 2015 the domestic and municipal water demand is predicted to increase by 45% in Southern Mozambique and by 35% in the Central region of the country. With steady growth in the large industrial sector, the water demand for large industries is estimated to increase by 70% in the South and by 60% in the Central Mozambique. The expected growth in hydropower production is likely to require an increase in peak capacity. The Government also intends to double the current irrigated area in the medium term, which would be mainly achieved through rehabilitation of the existing irrigation schemes, using public and private funding.

If these plans are realized, along with some projected increase in urban water demand, it is expected that by 2015 such southern rivers as Umbeluzi and Limpopo may have negative water balances against the present level of water yields. This means that the amount of usable and available water resources depends heavily on the development of storage and diversion infrastructure. To satisfy the future water needs to support the envisaged economic growth and sectoral development, substantially more water infrastructure will be needed to augment available supplies and increase water yields in the potentially water scarce river basins in the Southern and Central regions. Looking into the future, the economic development pressure will likely make the problem of seasonal water shortages more critical in the other river basins of the country as well.

Region	Domestic Water Supply	Industrial Water Supply	Irrigation	Livestock	Forestry	TOTAL
South	128	15	202			345
Center	89	4	206	66	29	394
North	73		230	90		393
TOTAL	290 (25.6%)	19 (1.7%)	638 (56.4%)	156 (13.8%)	29 (2.5%)	1132

Data Source: NWDP1, BB5 Phase 1 Report: Black & Veitch International, 2004

Table 2.1. Composition of Total Consumptive Water Use in Mozambique by Sector and by Region (million m^3)

4 Addressing the Challenges

4.1 Key Strategic Issues in the Main Water-Using Sectors

Irrigated agriculture and potable water supply are the main consumptive water using sectors in the Mozambique economy (Figure 3.1). Agriculture, which includes irrigation, forestry and livestock, is by far the largest water user, accounting for 73% of the total water consumption, while domestic and industrial water supply constitute about 28% (2% and 26% for industrial and domestic water supply, respectively). Hydropower is the most important non-consumptive user of water, producing more than 80% of the electricity in the country. Strategic choices for the development of these sectors should underpin the country's development objectives in the long- and medium term. They also determine the evolution of water demands and requirements in the respective basins and are therefore an important factor in developing national and regional water resources strategies. The sections below discuss the key strategic issues in the irrigation, water supply and sanitation and hydropower sectors, and the environmental use of water.

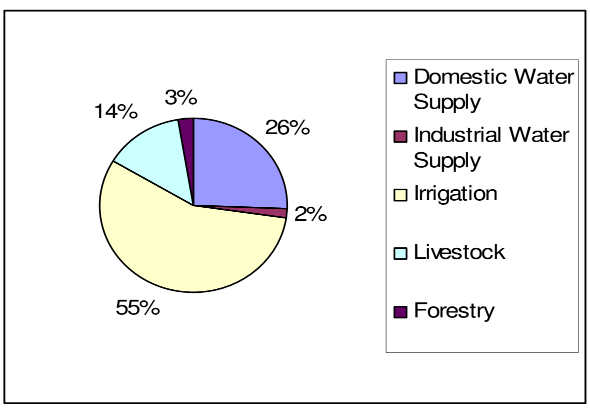


Figure 3.1. Consumptive Water Use by Sector

4.1.1 Irrigation

Rain-fed farming in Mozambique is subject to frequent droughts, and food security is low. The climate of Mozambique imposes the risk of harvest loss in rainfed agriculture exceeding 50% in all regions south of the Save River, and can reach up to 75% in the interior of the Gaza province. The centre and north regions of the country have more appropriate conditions for rainfed agriculture, where the probability of good harvests during the wet season is 70-95%. The north of the Manica province and the south of the Tete province are excluded from this Centre-North region, as they have a risk of harvest loss in rainfed crops of usually more than 50%. Irrigation efficiency is reduced to 25-50%, mainly in the surface irrigation areas of smallholder farmers. Agricultural companies, which mainly use sprinkler irrigation, have efficiency rates of up to 70%.

Most agriculture is subsistence smallholder farming, with farm sizes in the 1 to 2 ha range, generally growing food staples such as maize and cassava, except in the pastoral areas (such as in Tete, Sofala and Gaza) where livestock raising is practiced. There are also a relatively small number of large scale commercial farms, which produce cash crops such as sugar and tobacco.

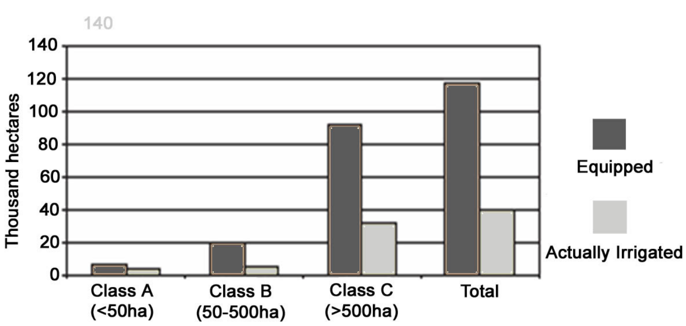
The irrigation potential. In Mozambique increasing irrigated agriculture has been identified as a critical factor in the alleviation of rural poverty and achievement of food security. Irrigation can enable subsistence farmers to maintain productivity in times of drought and to diversify into cash crops. It can provide opportunities at the small, medium and large scale for secure, profitable and sustainable business.

The country's tradition of irrigation dates back to the pre-independence period. In 1968 irrigated lands totaled 65 000 ha, out of which 72% were located in the Maputo and Gaza provinces. In 1973 this area had increased to 100 000 ha due to the establishment of sugar companies and Limpopo settlers in the southern provinces of Maputo and Gaza. Irrigation was mainly practiced by the Portuguese settlers who exploited these lands, while Mozambicans did not use irrigated agriculture. After independence in 1975, the irrigated area in the country was increased by about 20 000 ha, and the total equipped area reached almost 120 000 ha in the early 1980s. Most of the developed areas were located in Maputo and Gaza provinces, where significant water development works took place including construction of the Pequenos Libombos Dam on the

Umbeluzi River, the Corumana Dam on the Sabie River and the Massingir Dam on the Elefantes River. In the years following independence, the government encouraged the exploitation of existing large irrigation schemes by state companies. These companies however became a symbol of inefficiency, mismanagement and the initial gains were lost due to the deterioration of the irrigation infrastructure.

The area of irrigable land in Mozambique has been variously quoted as 2.7m to 3m hectares[xv]. This compares with the total land area under permanent cropping estimated at 4.5m hectares. More than half of the potential irrigable land is in the Zambezi valley. Other basins included in the estimate were the Limpopo/Incomati, Pungué/Buzi, small rivers in Zambézia, and the Lugenda and other rivers in Niassa and Cabo Delgado. These estimates, made in the 1970s and checked independently at the time, should now be regarded as optimistic. Allowances need to be made for the lack of hydrological data, the decreases in flow to Mozambique in the southern transboundary rivers, and lessons learned over the last 30 years about the vulnerability of large irrigation areas in flat terrain to high groundwater tables and salinization. Nevertheless, even taking these factors into account, there remains substantial untapped irrigation development potential, especially in the Zambezi valley.

Currently, 118 120 ha are equipped for irrigation, of which 40 063 ha are actually irrigated, consisting mainly of large schemes over 500 ha (Figure 3.2).



Source: FAO AquaStat – Mozambique

Figure 3.2. Equipped and actually irrigated areas

The use of irrigation is substantial among commercial farms (over 30% is reported), but low among smallholders. Surveys indicate that the proportion of farmers using some form of irrigation rose from about 3% in 1996, to 11% in 2002, but these figures are regarded as unreliable. Many who reported that they use irrigation probably have done so rarely, or only for very small garden plots.

The two – pronged approach to irrigation development with a focus on smallholder and commercial farming. The emerging priorities for the World Bank assistance in the irrigation sector in Mozambique in the short- and medium term include support to smallholder irrigation as well as promotion of irrigation for commercial farming. In the classification of water interventions illustrated in Figure 3.3 later in this Chapter, development of smallholder irrigation is an example of poverty-targeted water service intervention with the objective of alleviating rural poverty and improving food security in the short- to medium term (type 4). However, to provide the basis for growth and opportunities for the poor in the longer-term, type 3 interventions - broad policies and investments that affect irrigation development and management - need to be considered. This includes development of market-oriented irrigation polices[xvi] to encourage commercial farming and large scale irrigation and support to better coordination between water and agricultural ministries in developing an integrated approach to irrigation sector development. Expansion of commercial irrigation could be driven by private sector financing. However the role of the Government would be to put in place the legal, institutional and regulatory framework necessary to encourage commercial farming and improve water availability for irrigation through development of additional multi-purpose water storage infrastructure. Pilot initiatives to test new approaches in the management of irrigation schemes with farmer-led management of irrigation water delivery systems could be another high-priority area for interventions in the irrigation sector.

Smallholder irrigation opportunities and benefits. Agriculture in Mozambique is almost entirely dominated by smallholders. The agricultural economy is a major source of livelihood, and food represents about two-thirds of total consumption, especially among the rural poor. An estimated 70% or about 12.5 million people live in rural areas. Average cultivated area per household is only about 1.4 hectares. In 2003, there were an estimated 3.2 million farm families cultivating some 4.5 million hectares. Medium- and large-scale farmers are almost insignificant in terms of land area and numbers of farms. Two-thirds of agricultural production is for home consumption and only 5% is generated by large-scale agriculture. Most of the agricultural land area for small (less than 10 hectares) and medium farms (10-50 hectares) is cultivated for basic food crops. By contrast, large farm enterprises (more than 50 hectares) produce mostly cash-crops.

In the highly variable climatic conditions, conversion of rain-fed smallholder farms to irrigation has been shown to have a number of benefits. Food security is boosted enormously for those farming families, with annual risks of food shortfall declining from 20% - 40% of years with food shortfall, down to near zero. Productivity increases substantially, as farmers can harvest two crops per year from single plots, and can inter-plant vegetables between rows of maize and other crops. Dietary diversity is thus also achieved. Farmers also include cash crops among their production, gaining income important in supporting family health and education. Multiplier effects, including benefits to those trading with irrigation farming families or processing farm produce, result in substantial indirect benefits.

However, the opportunities for an increase in smallholder irrigation in Mozambique and, consequently, its poverty alleviation effect, should not be overestimated due to the limited access to water for the majority of agricultural smallholders. In Mozambique, unlike some of the countries which occupy the southern African plateau, useful groundwater sources are scarce. There is some in the sandy coastal plain where soils are often poor, and in alluvial valleys where surface water is often more conveniently available. The most common occurrences of groundwater are in the "machongos", which are wetlands with accumulations of peat, often at the eastern foot of the escarpments in the southern provinces. These are used by farmers for production of crops in the dry season through careful control of groundwater levels.

Apart from these, most opportunities for smallholder farmers to access water will be surface water. The density of streams which present surface water opportunities for small developments, varies with rainfall and topography. The densest stream networks are in the areas of higher rainfall, such as the upper Pungué basin in Manica province, the Zambezi delta, and much of the Zambézia, Nampula and Niassa provinces. Nevertheless, the proportion of smallholder farms with economic opportunities for irrigation, excluding those already irrigating, is not likely to be as much as 10%. This is because, even in those areas, most plots are too distant from the water source or are elevated well above it.

The greatest pay-off for increasing smallholder irrigation, in terms of food security and poverty impact, is likely to be in those provinces where the population of poor subsistence farming families is highest, where there are the highest numbers of farms with inexpensive access to water, and where soils and topography lend themselves to irrigation. Also, irrigation services are just one of several critical inputs to improve agricultural productivity (along with the availability of inputs such as seed and fertilizer, post-production processing, information, credit, transport and marketing) and it needs to be complemented and coordinated with a broader strategy on smallholder agricultural development.

The World Bank Mozambique Agricultural Strategy suggests[xvii] that irrigating a smallholder farm results in an increase in production of 2 to 4 times the rain-fed production. Conversion of 5% of the productive rain-fed land in selected areas to irrigation could therefore be assumed to increase agricultural production by about 10% on the average. It also suggests that the multiplier effect of the new irrigation would be between 1 and 2. Thus the economic effect of converting 5% of the suitable agricultural land to irrigation would result in the increase of 15% in economic activity in the respective areas, if one assumes a multiplier of 1.5. However, the whole of the production from the irrigated land, plus the additional indirect benefits, would be much more protected against the effects of rainfall variability than the remaining rain-fed agricultural production. Another important benefit of smallholder irrigation programs (even if implemented in a limited scale) would be the development of a culture of irrigated farming and the skills and knowledge of farmers to manage the irrigated production of the range of crops suitable for the climate and soils, and to market them. The non-existence of such a culture of irrigated farming is one of the reasons for the lack of success of the equipped irrigation areas of the south.

The potential scope of *smallholder irrigation development* seems to be small compared to the size of the smallholder farming population that is exposed to risks of food shortfall due to droughts (and floods). Probably only about 5% of the smallholder population would directly benefit, and then only in a few provinces. The effectiveness of this intervention could increase if support to smallholder irrigation is included in a broader context of *small scale water resources development* programs and projects. This would include community-based sustainable management and development of water resources of small streams, groundwater resources, and local (micro) watersheds in the poorest areas (for example, in Nampula Province).

The possible activities could include construction of small hydraulic structures and local scale hydropower units, water harvesting, flood protection and water resources protection against polluting activities. This should also be coordinated with regional strategies and plans for feeder road rehabilitation and construction, rural water supply and sanitation (including small towns), and rural electrification.

Support to commercial farming. A recent World Bank exploratory mission on irrigation in Mozambique has identified priorities for the Bank's support in the irrigation sector in the next CAS period (FY08-FY11). The assistance would focus on a limited number of high potential areas where a number of conditions for success are being met, particularly in terms of connection to markets. It has been identified that these focus growth areas will include the Maputo, the Beira-Chimoio, and the Zambezi corridors[xviii]. Agricultural growth will also need to focus on priority agricultural value chains where Mozambique has a proven comparative advantage, such as sugar cane, rice, horticulture and fruits. Improving production of each of these will require a targeted approach that comprehensively addresses the structural constraints, while focusing on high potential areas. The mission has identified the following priorities:

a) *Promotion of commercial fruit and horticulture production in the Beira-Chimoio corridor*. Following up from work led by CEPAGRI and the Horticulture Task Force (HTF) and in line with recommendations from the CWRAS, one particularly attractive model involves the promotion of PPP in commercial horticulture production through development of storage in the upstream parts of the Pungué river. Associated investment in this growth area would be required in infrastructure (roads, but also improvements of Chimoio airport and Beira port), in processing and exporting facilities (cold storage in Chimoio and Beira) and in providing better access to adequate financing.

b) *Promotion of commercial fruit and horticulture production in the Maputo corridor*. In line with the above, fruit and horticulture production should be further supported in the Maputo area, where it can benefit from the proximity with the urban market and with other market opportunities in nearby South Africa, as demonstrated by the recent market study piloted by CEPAGRI. Ongoing initiatives (greenbelt of Maputo) could be upscaled through targeted investments in infrastructure to improve water management and promote collaborative arrangements between commercial farms and smallholders.

c) *Promotion of commercial sugarcane production in the floodplains of the Pungué (Beira corridor), Limpopo and Incomati rivers (Maputo corridor).* Bio-fuel would offer interesting opportunities that are currently being analyzed through an ESW. The ADB is also conducting a feasibility study in production of sugarcane for ethanol. Contract farming arrangements with smallholder producers need to be further promoted. Investments would include transport and processing facilities. Parallel measures need to be taken to attract private investors.

d) *Smallholder rice and horticulture production in the Zambezi corridor*. There is scope for investment in irrigation combined with market development in the Zambezi valley corridors (Quelimane and Nampula-Nacala). This could take the form of support to the dissemination of private irrigation technologies and related support services –primarily for vegetables (onions, tomatoes), as well as through investment in small-scale community-based irrigation schemes (10-50 has), provided the investment costs can be reduced and support can be provided on a cost-sharing basis to help adopt more intensive technologies, facilitate access to inputs and improve water management.

4.1.2 Hydropower

The country has four major hydropower stations at the Cahora Bassa, Chicamba, Mavuzi and Corumana dams for the production of electricity (Table 3.1). Actual power demand is about 240 MW (2002), with an annual energy consumption of 1300 GWh. 80% of the

	Power (MW)	Turbine		Location	
		Head (m)	Discharge (m^3/sec)	Province	River
Cahora Bassa	2075	120	2000	Tete	Zambeze
Chicamba	34	50	60	Manica	Buzi
Mavuzi	48	160	23	Manica	Buzi
Corumana	16.6	36	25	Maputo	Incomati

Table 3.1. Existing Hydropower Stations
Source: Water Resources of Mozambique, DNA, 1999

current energy production in Mozambique comes from the Cahora Bassa hydropower plant (HCB) with an installed capacity of 2075MW. In the coming years EDM expects to cover the demand growth from additional power allocation from the HCB and with the surplus still to be exported to South Africa, Zimbabwe and probably Malawi.

Installed capacity at Cahora Bassa is 2075 MW, with an average potential production of about 10000 GWh/y. The HCB is currently owned by the Portuguese (82%) and Mozambican governments (18%) respectively although agreement has been reached to transfer majority ownership to Mozambique depending upon successful financing of the transfer being concluded. The conclusion of these arrangements will determine the amount and conditions of the power allocation among the off-takers, including EDM.

Given the increasing power demand in Mozambique and in the region, particularly in South Africa, the water management strategy suggests that the hydropower development on the Zambezi River should be an investment priority in water resources development. Initial feasibility studies undertaken by UTIP showed that the proposed Mphanda Nkuwa Dam located between Cahora Bassa and Boroma, could be highly economically and commercially viable, and some of the investments could be provided by the private sector. Besides the main hydropower potential concentrated on the main stream of the Zambezi between Cahora Bassa and Lupata, the tributaries Luia, Revubué, and Luenha also present good opportunities for hydropower developments. In addition, EDM is currently undertaking studies on hydropower potential on the Lurio river.

In addition to Cahora Bassa North, the Mphanda Nkuwa project has been promoted by the GoM partly as a means to gain independent control of both the management of the Zambezi and the potential power market. Now that Cahora Bassa is being renegotiated, there is the possibility (and an imperative) to rethink Mphanda Nkuwa on its own merits in the context of the development of the Zambezi within Mozambique and the Zambezi basin as a whole. There would now be greater possibility of approaching the Mphanda Nkuwa development from a more multi-purpose perspective in addition to its hydropower potential. The prospect of construction of the proposed Mphanda Ncua and Cahora Bassa North developments, together with the negotiations for a change in ownership of Cahora Bassa, provide an important opportunity to ensure that environmental and social considerations are taken into account by the operational regime of Cahora

Project	Power (MW)	Turbines		Annual Energy Production	Location Province
		Head (m)	Discharge (m^3/sec)		
Cahora Bassa II	1200	120	1320	6800	Tete
Mphanda Nkuwa	1780	58	3400	12450	Tete
Alto Malema	80	27	60	229	Zambezia
Lupata	654	80	3025	4960	Tete
Boroma	444	38	60	3240	Tete
Luia	234	98	350	975	Tete
Revubue	120	80	60	510	Tete
Mutelele	50		190		Niassa
Lurio I	120				Nampula/Cabo Delgado
Lurio II	120				Nampula/Cabo Delgado
Lurio III	60				Nampula/Cabo Delgado
Mavuzi I, II	60		215		Manica

Table 3.2. Potential Hydropower Undertakings
Source: Water Resources of Mozambique, DNA, 1999; Communication with WB Staff in Maputo Office

Bassa and the proposed new developments, whilst still achieving major growth objectives.

Potential hydropower generation in Mozambique is quite large. According to EDM, about 13000 MW, producing 65000 GWh/y of energy, can be economically developed in Mozambique. About 70% of this potential (10000 MW, 45000 GWh/y) is concentrated in the Zambezi watershed, and most of it on the Zambezi river (Table 3.2).

The extent to which the different uses compete for water or are complementary varies. Irrigation and power generation can often be complementary, if the irrigation off-take is downstream of the power station outlet. One example is the proposed installation of a 28MW power station at the existing Massingir Dam, currently a single purpose dam for irrigation, which is being rehabilitated. Power transmission is a large component of the cost, however the cost of power delivered to the grid in Mozambique is attractive compared to current grid costs and charges, so the scheme seems likely to go ahead.

A master plan for Mozambique grid development has been prepared and Mozambique is now seeking to prepare a power generation master plan. The grid has two main centers of demand. Maputo, which has the highest demand by a large margin, and Beira. There are long transmission lines to small centers in the north. Additional sources of generation in the north would reduce the vulnerability of these parts of the grid and would reduce transmission losses. Therefore identification of possible small hydropower sources in Niassa and Zambezia would be very useful.

The Southern African Power Pool (SAPP) is at an early stage of development and has started as a co-operative pool, i.e. a pool under which members would seek to maximize economic and system reliability benefits through trade, while retaining maximum autonomy for individual members. In the longer term the SAPP aims to facilitate the development of a competitive electricity market in the SADC region. It is likely to take several years at least before this can be agreed and steps taken to achieve it.

The financing of multi-purpose developments which include hydropower can be attractive to private capital through public-private partnerships because hydropower produces a reliable stream of revenues. In such investments the risks are shared with each sector adopting risks for which it is most suited. The public sector takes responsibility for exploration, geological, environmental and social risks and their mitigation, whilst the private sector assumes responsibility for financing and operating the electricity generation station. However, for this potential to materialize, improvements need to be made in such areas as contracting and pricing practices, the electricity market structure and trading rules, and water use priorities

4.1.3 Water supply and sanitation

According to the status report of WSS MDG achievement in Africa undertaken by the Government of Mozambique and active sector donors[xix] in April 2006, Mozambique has the potential to achieve the MDGs for water supply in its major cities (representing 75% of the urban population). The coverage level in water supply for the urban areas is 56% with the target access rate of 70% (for water supply in urban and rural areas). New institutional structures, reform of sector finance, and increasing cost recovery suggest positive progress in this area. Supported by the World Bank National Water Development Project II, Mozambique has put in place private sector management of the water supply systems of Maputo and four regional cities. The Government established FIPAG (Fund for Water Supply Investment and Assets) as the agency responsible for major urban water supply. It also set up a regulating authority, CRA (Council for the Regulation of Water Supply). More recently, the Government has sought to improve water supply services in four large towns by adding them to FIPAG's portfolio (Beira, Pemba, Nampula and Quelemane). A further such step covering several towns in the central provinces is also getting under way.

By contrast, rural areas and small towns have been slower to implement reform strategies, while sanitation in both urban and rural areas remains limited to household initiatives. The coverage level for water supply is about 27% for the rural areas (with the MDG target access rate of 70% for 2015). Access to sanitation is 33% for urban as well as for rural areas, while the target rate of sanitation coverage is 50% (45% for urban, 60% for rural). The Government is finalizing a Strategy for Rural Water Supply and Sanitation for the period from 2006 – 2015. The objectives of the strategy are to define realistic intermediate targets for increasing the coverage in rural WSS, estimate investment requirements, improve the financial planning mechanisms, and outline the way forward for decentralized implementation, management and capacity building at the provincial and district levels.

The priority focus in urban water supply, where the critical mass of water production infrastructure is already in place for all major cities, is gradually shifting towards improvements in coverage, operation and management, and achieving financial sustainability. There is significant potential for water conservation and demand management to increase the efficiency of the systems by reducing the current water losses due to leaks and inefficient water use[xx]. Implementation of these measures may also result in adjusted water demand curves in the medium- and long-term which may save significant public resources by postponing the need for investments in additional bulk water sources and/or reducing the scale of future investment requirements.

4.1.4 Environmental Use of Water

The environment uses water to sustain river health and ecological functions. In order to preserve an acceptable balance within a specific watercourse, it is necessary to ensure that an adequate ecological reserve is maintained in the river basin – the reserve refers to both the quantity and quality of water in the river. The ecological reserve of water ensures the ecological integrity of rivers, estuaries, wetlands and groundwater resources. Water allocated to the environment (and to some extent to hydropower) is also used for recreational activities. Recreational use of water in Mozambique is expected to increase due to the Government's policy on development of tourism industries. In Mozambique, there are currently 34 nature conservation and protection areas, covering more than 10% of the country's total area. Many of these biodiversity rich areas are under threat from unsustainable use of natural resources, including water resources.

The environmental requirements for water, in quantitative and qualitative terms, need to be developed for each river basin in Mozambique. Water allocation for the environment is also an important tool in the negotiation of joint basin agreements in the international context of Mozambique's major river basins. This requires that sufficient water is maintained within the system to meet environmental requirements in downstream riparian states, thus providing another important dimension to the negotiation of basin agreements and inter-national allocation of water rights.

4.2 Defining Responses – A Framework for Priority Setting

4.2.1 Water for Growth and Poverty Reduction

The conclusion from the analysis in Chapter II is that the magnitude of the cost to the national economy due to water vulnerability is extremely high. The Government of Mozambique and international aid community need to recognize the high degree of dependence of the country's economy and its social well-being on water by assigning to water management and development a greater priority in the national development agenda. The way a country manages its water resources in the face of limited endowments and high variability can greatly influence its water vulnerability.

To determine interventions in the water sector which should receive priority support, it is necessary to take into account the relevance and consistency of selected interventions with the country's development objectives and poverty reduction targets identified in the national development plans and strategies, and, specifically, in the recently approved PARPA II. It is also necessary to focus on systemic and urgent challenges in the country's water resources development and management, and the relevance of selected interventions to the National Water Management Strategy and its priorities.

Figure 3.3 illustrates a useful framework to analyze the expected impacts of the water sector interventions in terms poverty reduction. Type 1 interventions are broad-based water resources interventions (including major water infrastructure) that provide national and regional economic benefits to the whole population, including the poor. Type 2 interventions aim at improving water resources management in ways that directly benefit the poor. Recent research by the World Bank has shown that the average incomes of the poorest fifth of society rise proportionally with overall incomes[xxi], inferring that the poor generally would benefit from broad-based growth-inducing investments in water resources management and infrastructure. To support rapid growth that is also pro-poor, a careful balance must be maintained between economic growth and poverty reduction criteria in making investment choices. An appropriate water sector investment strategy is a blend of all the types of interventions illustrated in Figure 3.3.

The proposed interventions should be realistic with regards to the nature of the challenge they are addressing and the timeframe and resources necessary to implement them. The criteria to apply to determine priority investments should take into account:

- The need to weigh broader economic development targets against more immediate poverty reduction objectives (Figure 3.3);
- Regional perspectives and plans for economic development to address regional disparities in poverty and well-being that vary considerably among the districts, and between rural and urban areas;
- Inter-sectoral perspectives in terms of economic value of water used in different economic sectors;
- The connections between resource use and service management because, on one hand, the culture and principles of water use by major water using sectors have an important influence on water resources management and the water security situation at the local and national scales. On the other hand, inadequate water resources infrastructure and weak water resources management increases the risk of unreliable and unsustainable water services;
- The need to coordinate and sequence investments in water infrastructure and water management.

4.2.2 National Inter-Regional Perspectives

One of the issues raised by PARPA II is the need to address regional disparities in poverty and well-being that vary considerably among the provinces, and between rural and urban areas. Mozambique has achieved considerable results in poverty reduction since 1992. In terms of regions, poverty declined more in the rural areas than in urban zones—by 16% and 10.5%, respectively. Poverty reductions were found in almost all the provinces of central and northern Mozambique, except for Cabo Delgado, where poverty increased. In the south of the country the scenario is nearly the inverse. Poverty increased in two provinces there—Maputo province and Maputo city. In Inhambane, a marginal reduction—from 82.6% to 80.7%—was seen, making this the country's poorest province. In rural areas, the enormous variability in living conditions reflects the significant year-to-year fluctuations that are typical of farming on the dry, non-irrigated lands that are the primary source of employment for most Mozambicans. The effects of meteorological changes are exacerbated by both internal and external economic factors such as exchange rates and the prices of oil, cotton, cashew nuts, and corn.

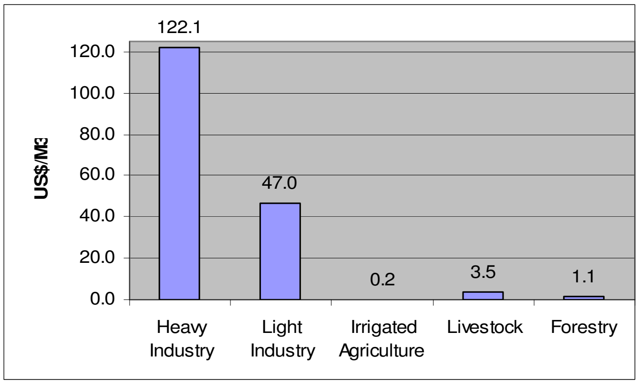
In terms of achieving higher economic returns, it makes sense to focus infrastructure investments around the main urban centers and along the primary development corridors, where production and trade are concentrated (this would include the Beira corridor for West-East trade, the Maputo corridor in the South, and the Zambezi corridor). However, the poverty reduction effect may be higher if priority is given to developing

Water Issue \ Intervention	Broad	Poverty-targeted
Resource development & management	**Type 1**: Broad region-wide water resource interventions	**Type 2**: Targeted water resources interventions
Service delivery	**Type 3**: Broad impacts through water service delivery reforms	**Type 4**: Targeted improved water services

Source: World Bank Water Resources Strategy, 2003

Figure 3.3. Water Interventions and Poverty Impacts

infrastructure and public services in regions with the greatest concentration of poor populations. Nampula, Zambezia, Inhambane and Cabo Delgado are the provinces with the highest concentration of poor population [xxii].



Data Source: BB5 background report for NWRMS, DNA 2004

Figure 3.4. Estimated value added per unit of water used by sector

4.2.3 Inter-Sectoral Perspectives

As discussed in Chapter 2, water plays a constraining role in the Mozambique economy. By choosing priorities for water resources investments and policy changes, the government affects water allocation between different economic sectors, enabling or constraining their relative growth.

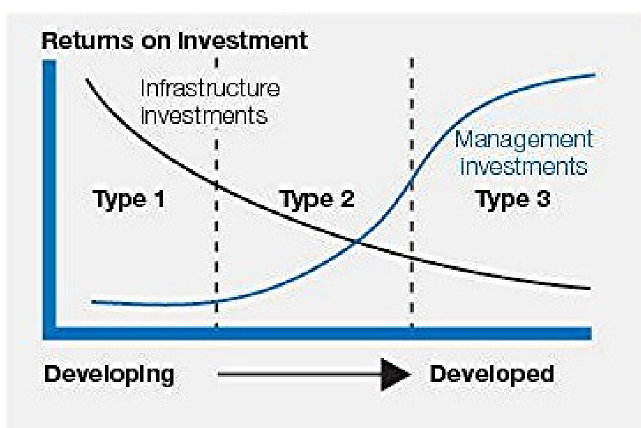
For the economy as a whole, the allocation efficiency of water use is achieved when it is not possible to increase further the value added for the economy by transferring water from one activity or sector to another. Conversely, if water is not being allocated and used in an efficient manner, economic welfare can be improved by transferring water to the sectors where it can make a larger contribution to the welfare of society. However, water use efficiency is often compromised in actual decisions on inter-sectoral water allocation by the importance of considerations of social equity and fairness, and poverty alleviation as a development priority. It must also be recognized that these decisions are not made in a political vacuum and hence the political economy must also be considered.

Currently the water-using sectors in Mozambique perform very differently in terms of the efficiency of water use. Agriculture generates very low value-added per cubic meter of water used, while value-added per unit of water used in industries is significantly higher (Figure 3.4).

However, it is also important to take into account the social impact of water use in each sector. For example, while the apparent economic value of water use in agriculture in Mozambique is low, agriculture plays a critical role in providing employment in rural areas where there are few alternative sources of livelihood. Most of Mozambique's rural population relies on subsistence agriculture, with self-employed farmers accounting in 2002 for 68% of total employment and non-agricultural employment for only 20%, and thus water allocation for agriculture has a high social priority.

4.2.4 Sequencing and Balancing Investments in Infrastructure and Management

Figure 3.5 illustrates different types of investments which can be made to increase the availability of water for productive purposes. In the absence of infrastructure, there are limitations on how water can be managed, regulated, stored and transferred. As infrastructure is developed and the resources reach higher levels of utilization, the options for further infrastructure are reduced and other methods need to be used to increase the availability of water such as reducing unaccounted-for water, improving water use efficiency etc. Worldwide experience demonstrates[xxiii] that countries typically focus first on supply-side solutions in water resources development at earlier stages of their development, shifting to more management-based ap-



Source: World Bank, China Country Water Resources Assistance Strategy 2002.

Figure 3.5. Returns on Investments in Infrastructure and Management

proaches as the resources base gets closer to full utilization. Mozambique is at a stage of development when infrastructure investments will have generally higher returns and will be more efficient in achieving water development objectives. This is because the current level of water related infrastructure development is so low that the resources are largely unmanageable.

Therefore, investments in the water resources sector should at present be a key strategic thrust in addressing water vulnerability in Mozambique. Increased water storage, control, and distribution infrastructure is needed to remove water-related constrains to the country's economic growth and development. At the same time, it is important that Mozambique recognizes the importance of sound water management and should continue to develop and improve water management practices in parallel with implementation of infrastructure investments.

4.3 Defining Responses – What Needs to Be Done

4.3.1 Achieving Water Security

Water security is a measure of (1) the ability of a country to continue function productively, both socially and economically, given its inherent water vulnerability characteristics, and (2) the adequacy of its water management response to confront this vulnerability. A country's water vulnerability can be reduced through development of adequate water infrastructure and improvements in water use practices and management approaches.

The minimum water infrastructure and institutional capacity required to ensure basic national water security can be described through the notion of a "minimum platform of water institutions and infrastructure"[xxiv]. Below this platform, society and the economy are not resilient in their response to the impacts of water shocks, and/or there is no reliably available water for production and livelihoods, and water is a significant obstacle to growth. The more vulnerable an economy is to water shocks, the higher the minimum platform of investments needs to be. ***For each country therefore it is important to determine what investments are needed to reach the minimum water infrastructure platform for ensuring basic water security.***

In the case of Mozambique, hydrological variability and frequent water shocks such as droughts and floods are the main water vulnerability factors, and mitigation of their effects is at the heart of achieving basic water security. The implication of this vulnerability is that large investments in water infrastructure and specifically, additional storage, are needed to buffer against temporal and spatial variability, protect against flooding and provide access to water during droughts. Irrigation infrastructure needs to be in place to ensure resilience of agricultural production to droughts. These interventions should be complemented and sequenced with water resources management improvements. Available data suggest that countries in Sub-Saharan Africa might need to invest between USD 150 and USD700 per capita to reach a level of water storage infrastructure equivalent to that in South Africa and thereby achieve a similar level of water security[xxv].

It is assumed that basic water supply and sanitation (WSS) services will be achieved with the attainment of the MDG targets on WSS. A recent WSP study[xxvi] estimated that to reach those targets, Mozambique would need to spend $110 million ($90 million for improving water supply services and $20 million for sanitation) annually over a 10 year period between 2006 and 2015 - a total of $1.1 billion. The order of magnitude of investment needed to reduce Mozambique's vulnerability to water shocks by 2020, based on the results of a regression analysis undertaken in the CEM study[xxvii], is $3.9 billion (or $205 per capita).[xxviii]

These estimates provide an indication of the costs of water infrastructure and management improvements necessary to achieve the basic level of water security by 2020. In terms of the economic analysis, in order for the benefits to the economy to exceed the costs and thus ensure that the investments are viable, the total investments on improvements in water supply and sanitation coverage and reduced vulnerability to water shocks should stay under USD 5 billion or USD 265 per capita. However, the actual costs to achieve water security will depend on the design of the program of interventions and the combination of infrastructure investments, technologies and supplementary measures chosen to improve water security. The challenge is to identify a diverse cost-effective portfolio of policy, investment and management interventions in the water sector as well as across the economy to strengthen the resilience of the economy to the risks of

Box 3.1. Impact of Hydrological Variability on Water Service Delivery

- During the 1982-83 drought in the Southern and Central Regions of Mozambique, the average flow in the Incomati river was only 165.1 million cubic meters, while in the previous last ten years it was 2, 547 million cubic meters.
- Flows of 6.5% of the normal discharge in the Incomati river and 16% of the average discharge in the Umbeluzi river, had alarming consequences for water supply of Maputo (with 900,000 inhabitants) and in the agricultural areas of Maputo and Gaza Provinces. The decrease in the annual flow of the Limpopo river reduced irrigation water supply in the river valley, permitting farmers to irrigate only 25% of the total rice area.
- The Corumana Dam, located on the Sabie river, serves to guarantee a secure inflow to the irrigation schemes and hydropower generation. According to the observed hydrological data, the Sabié River was registering a water shortage during winter 2003. The actual water volume was below 50% of Corumana reservoir full capacity, resulting in water supply restriction in the Sabié Region.
- In Northern Mozambique droughts affected water supply for domestic and municipal water needs. In September 2004 the Nacala dam that supplies water to Nacala city, had less than 5% of its reservoir net capacity. The situation necessitated emergency actions to provide water for basic human needs in the city.

Source: Communication with Mozambique DNA

hydrological variability, and to improve water services. In addition to infrastructure investments, interventions should include water conservation, improved water demand management and water use efficiency (especially in Agriculture), greater assurance of international waters, and improvements in river basin and community-level water management. Economic diversification and a shift away from water-dependent agricultural production and industries as well as from food self-sufficiency would also reduce water-related vulnerability of the economy and may substantially reduce the investment needs. Thorough investment planning and staged investment implementation are necessary to find a cost-effective solution to the water security problem.

4.3.2 The Need in Water Resources Infrastructure

Development of water infrastructure is at the heart of achieving basic water security in Mozambique. However, the level of investment in water resources development in Mozambique is currently insufficient. Inadequate water infrastructure hampers development of the main water-dependent economic sectors. Only 4% of the irrigation potential has been developed, despite available water resources and an agriculture-based economy. Access to safe drinking water supply is 60% in the urban areas and only 30% in the rural areas, while water borne diseases are the main cause of child illness and mortality in Mozambique. 20% of the hydropower potential has been exploited, and the electrification rate is only 5% - one of the lowest in the Southern Africa. Figure 3.6 illustrates the current low level of Mozambique's water infrastructure development. The expectation of rainfall variability results in under-investment by potential investors in land improvements and agricultural inputs, which ultimately leads to low productivity and slows down economic diversification.

High hydrological inter- seasonal variability, and specifically, variations in the flows in the river systems from season to season, also increasingly reduce the efficiency of the existing infrastructure and diminish returns on the past infrastructure investments (Box 3.1).

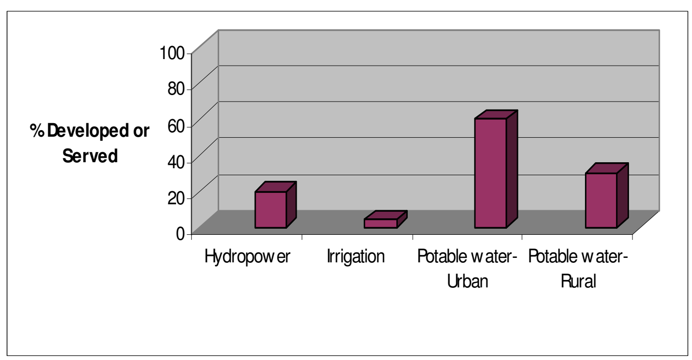


Figure 3.6. Water Infrastructure in Mozambique

Development of artificial water storage is necessary for ensuring reliable water supply during periods of reduced natural water availability (droughts) as well as for retaining excessive water during periods of floods. Available water storage is also a useful indicator of the level of development of water resources available for direct economic use. The amount of artificial storage per capita can also serve as an indicator of the level of a country's overall economic wealth and development, and is normally much higher in developed countries than in poorer ones (Figure 3.7).

At present, despite the high vulnerability of Mozambique to frequent droughts and floods, flood control and drought management infrastructure remains underdeveloped providing *inadequate storage capacity*. Mozambique has 12 major dams with a total capacity of about 3457 m^3 per capita, including the Cahora Bassa storage. Excluding the Cahora Bassa Dam which accounts for more than 90% of the country's storage capacity (and which is operated as a single-purpose facility to maximize hydropower generation), the storage capacity per capita is only 330 m^3, placing Mozambique among the Southern African countries with least developed water infrastructure (Figure 3.6). The total useful storage capacity represents 21% of the mean annual flow of the country's rivers, including Cahora Bassa. If Cahora Bassa is excluded, the remaining 5800 Mm^3 of useful capacity represents only 5% of the mean annual runoff of the country's rivers, excluding the Zambezi. In general, a storage capacity of 10-40% of the mean annual runoff would be necessary to utilize 50% of the mean annual flow, with 80-90% reliability.

Multipurpose reservoirs are required to satisfy a wide variety of needs including flood control, water supply and irrigation, power generation, navigation, and environmental requirements. Other infrastructure measures needed include construction of embankments and dykes to protect against floods, and small scale water sources (small dams and boreholes) to provide access to water during droughts. Infrastructure development needs to be complemented by sustainable water resources management to balance both consumptive and non-consumptive demands by water-using sectors with the available, renewable freshwater resource at the river basin level.

4.4 The Response - Additional Storage Capacity

The National Water Management Strategy[xxix] emphasizes the vital importance of multipurpose water storage development in Mozambique to mitigate these effects. The following are the priorities identified through the CWRAS process for the development of additional storage.

4.4.1 In the South

In the Southern basins, where water demand is high, droughts are frequent and most of the water originates outside of the country, the construction of large storage reservoirs to store water from the wet seasons for the use in dry periods is required. The development of the infrastructure should be undertaken in the context of integrated water resources management of the international river basins supplying the south which will include the need to revisit some of the existing agreements in particular to address low flow drought situations.

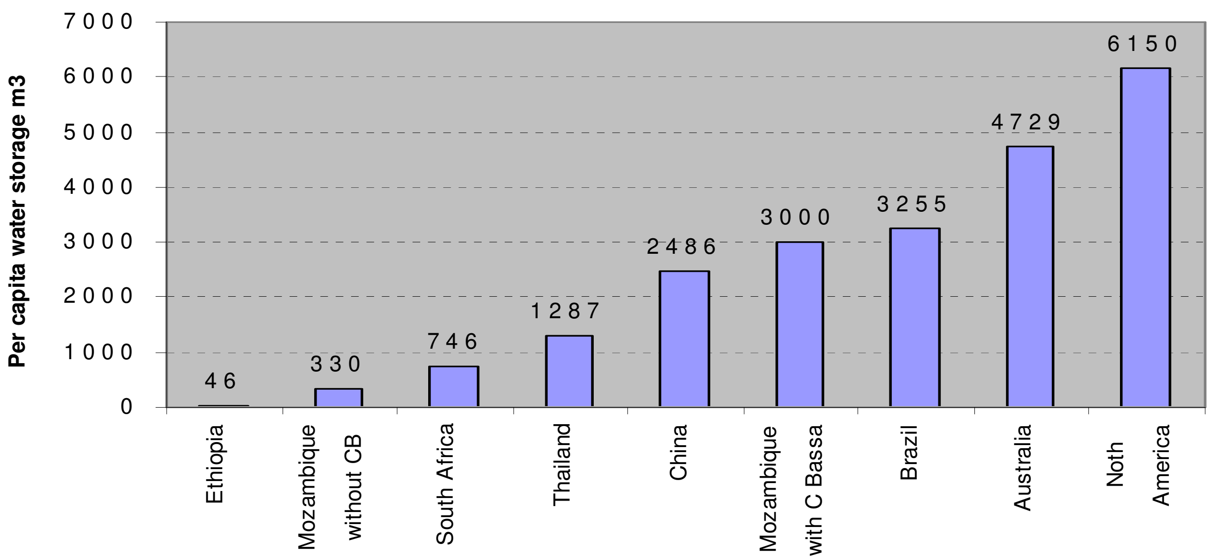


Figure 3.7. Water Storage per Capita

A key priority in the South in the short-term is the construction of additional storage capacity to resolve a growing problem of water supply for the city of Maputo. Currently, the city receives water from the Umbeluzi river, using flows regulated by the Pequenos Libombos dam. However, with the projected growth in water demand, Maputo is already showing indications of shortages. The losses in Maputo in terms of unaccounted for water (both through unrecorded consumption and leakage) presently are in the region of 55%. In addition to the provision of storage, reducing unaccounted for water is a non-infrastructural, resources management approach to increasing the available water and postponing the need for the next incremental increase in storage. The current European Union / European Investment Bank investment project in Maputo of approximately $200m is aimed at, amongst other activities, increasing in-city storage, increasing treatment capacity and decreasing unaccounted for water. It is anticipated that this will move the shortage crisis from 2007 to 2012. By 2012 increased bulk water resources will be needed which will require storage.

In order to examine the implications of different options for the development of water storage to meet future demands from the Incomati River, a detailed preliminary study was undertaken in June 2007, the report of which is entitled "Preliminary Economic Analysis of Maputo Bulk Water Source Development". The report forms an addendum to this CWRAS and is attached. The objective of the study was to determine the scheduling of future infrastructure developments and to examine the implications of competing water demands from urban / industrial needs and agriculture. The summarized conclusions are that:

1. Growing water needs for the Greater Maputo area require urgent investments in completion of the Corumana dam in order to meet the shortage in water supply for Maputo in 2011/12. Construction of the Moamba Major dam will be also necessary to meet the projected future demand for the urban and industrial development of the Greater Maputo area. The completion of the Corumana Dam is projected to meet the needs of the Greater Maputo Area from 2012 to 2028 and the Moamba Major dam from 2028 to 2041 which was the planning horizon of the analysis. Within this overall strategy there are possible permutations, one of which would require the commencement of the implementation of Moamba Major in 2012.

2. Ultimately the full yields of both the Corumana Dam heightening and the Moamba Major Reservoir will be required to meet the needs of the greater Maputo urban and industrial area. Surplus water yields will be temporarily available for other uses during some years directly after completion the Corumana dam and after completion the Moamba Major dam. This temporary surplus of yield could possibly be used by other water uses provided that the water allocation for such uses can easily be withdrawn when the water is needed for the urban supply.

3. Given that the existing water yield from Corumana is not used efficiently, and that there is an established future demand from Maputo, any permanent allocation for irrigation of the additional water made available by upgrading the Corrumana dam should not be permitted. Even if this water is used for production of such high value crops as sugar cane and would bring employment and other additional benefits, it will not justify the investments that will be required to find alternative supplies from more expensive sources for Maputo water supply in the future. This water needs to be reserved for future urban and industrial use.

4. Any determination of the economics of a scheme such as bio-fuel production or other irrigated crop production in the South should build-in a time limitation on the availability of water. Otherwise the loss of investments when water is redirected for higher value use would not be factored into feasibility considerations and would cause difficult competing water interests.

A degree of drought risk would remain, especially in the years prior to developments being commissioned and filling (which may take some years), which would be exacerbated if the upstream riparians increase their irrigation diversions further. Indeed increasing storage in Mozambique could perversely result in upstream riparians increasing water use on the mistaken assumption that Mozambique no longer faces any risk because of the storage. This would result in upstream countries utilizing the benefits that would otherwise have accrued to Mozambique from these investments, and would reduce further the options available to Mozambique.

It is understood that one of the motivations for the construction of the Moamba Major Dam is to secure Mozambique's international water rights on the Incomati. This is a very legitimate concern given the increasing pressure on water resources in the region. At issue is the principle of "Prior Appropriation" in international water law where developments undertaken by a riparian state lay claim to a certain quantity of water which thereafter constrains other states from undertake any developments which would reduce the rights already secured by the first state. However, undertaking investments which at the present are not the most economical option is a very costly way of securing such rights. There are other solutions which need to be fully explored and exhausted before taking the most costly option. Existing treaties and the SADC Protocol on Shared Watercourses should form the basis of securing future water rights without being forced into uneconomical investments at present. Although the construction of Moamba Major Dam is at present not the least cost option, it may well become an option in the future as other water sources are developed and the demands for water in the south increase - Mozambique needs to guarantee through legal processes that that option remains open.

Mozambique should therefore consider the need to pursue several further objectives in transboundary negotiations in the South. One would be to deepen the existing agreements by establishing detailed arrangements for the riparian countries to share the burden of droughts. Another objective would be to establish agreed long term ceilings on consumptive water use including irrigation water use in all three countries. A third might be to share the costs of further water development in Mozambique to the extent that upstream riparians also benefit. There are three reasons for seeking these improvements: (1) to attain an equitable sharing of the costs and benefits of the available water and the risks of drought between the riparians; (2) to ensure that irrigation whether in Mozambique or in upstream countries does not grow to the extent that it conflicts with Maputo's water supply requirements in the long term, and (3) to guard against the effects of climate change, which is thought in this climatic regime to be likely to result in declining water yields.

4.4.2 Additional Storage on the Pungue

One of the highest priorities in water infrastructure development in the Center of the country is the construction of a dam on the Pungue river to improve water supply to the city of Beira. The dam's reservoir would provide water for rapidly increasing industrial needs as well as for irrigation, hydropower generation, flood mitigation, and forestry, and to satisfy environmental flow requirements to prevent the intrusion of salt water. The Bue Maria dam was planned for completion in 2015 with estimated construction costs of US$150 million. However, this option needs to be reevaluated in the light of recent studies which imply that the Pavua option could be economically and environmentally preferable[xxx]. The limited availability of large aquifers (with the exception of the Nhartanda Valley near Tete; the Licuari aquifer near Quelimane; and the Metuge aquifer near Pemba) requires that, in the short and medium term, small and medium size reservoirs be built for drinking water supply to cities and towns of the region.

4.4.3 Additional Infrastructure on the Zambezi

Given the increasing power demand in Mozambique and in the region, particularly in South Africa, the water management strategy suggests that the hydropower development on the Zambezi River should be an investment priority. It is expected that the proposed Mphanda Nkuwa Dam located between Cahora Bassa and Boroma, will be highly economically and commercially viable, and most of the investments could be provided by the private sector. Besides the main hydropower potential concentrated on the main Zambezi between Cahora Bassa and Lupata, the tributaries Luia, Revubué, Luenha also present good opportunities for hydropower developments.

The Mphanda Nkuwa project has been promoted by the GoM partly as a means to gain independent control of both the management of the Zambezi and the potential power market. Now that issue of ownership of Cahora Bassa is being addressed, there is the possibility (and an imperative) to rethink Mphanda Nkuwa on its own merits in the context of the development of the Zambezi within Mozambique and the Zambezi basin as a whole. There would now be greater possibility of approaching the Mphanda Nkuwa development from a multi-purpose perspective in addition to its hydropower potential. The prospect of construction of the proposed Mphanda Nkuwa and Cahora Bassa North developments, together with the change in ownership of Cahora Bassa, provide an important opportunity to ensure that environmental and social considerations are taken into account by the operational regime of Cahora Bassa and the proposed new developments**.**

Feasibility studies were conducted in 2002-3 on hydropower development options for the Zambezi River below the existing Cahora Bassa Dam and hydropower station. These studies indicated that the optimum would be a two stage initial development consisting of:

1. A first stage comprising the construction of Mphanda Nkuwa dam with a 1300MW hydropower station operating as a run of river system;
2. A second stage comprising the construction of a largely underground 850MW hydropower station at the north bank of the Cahora Bassa Dam, known as Cahora Bassa North.

The development would also include construction of a 1600 km long 400KV transmission system through Mozambique to the main demand centers in the south of the country.

The operating rules for the Cahora Bassa dam and power station, when completed in 1975, contained no provision for environmental flow releases or flood control. The lack of wet season high flows resulted in detrimental social, economic and environmental effects downstream. Ecological systems of much of the Marromeu Ramsar-listed wetlands, and other delta and riverine forests and wetlands that depended on regular annual wetting and drying, have changed to permanently inundated or permanently dryland ecologies. Flood recession agriculture could no longer be practiced, and the estuarine prawn fishing industry has declined. On the positive side, the dam has undoubtedly attenuated the peaks of a number of major floods since its construction.

Adaptation of the operating rule could result in partial achievement of environmental restoration and improved social and economic outcomes to downstream communities, at the cost of a proportion of hydropower revenues. A detailed analysis of the associated costs and benefits derived from the introduction of multi-purpose operational objectives for large scale hydraulic infrastructure within the Zambezi basin would provide valuable inputs to maximizing the sustainable economic returns on such infrastructure. Potential benefits include opportunities for increased productivity through recession agriculture practices, simulated controled floods to stimulate fish and prawn breeding, tourism benefits through reestablishing the natural environment in the Marromeu Reserve, reductions in saline intrusion in the coastal zone and partial restoration of coastal currents to former patterns.

4.4.4 Small and Medium Multipurpose Dams

Construction of smaller reservoirs could provide water supplies for human needs and livestock, and small-scale irrigation, and would be an important factor in

Box 3.3. Socio-Economic Impacts of Massingir Dam

The construction of Massingir Dam on a tributary of the Limpopo River in Mozambique has had significant impacts on the local economy. Migration to Massingir has been largely related to the construction of the dam or the benefits provided by the reservoir. The dam has permitted the development of small scale irrigation activities downstream from the reservoir. The scenic and wildlife attractions of the area have resulted in the extension of the Limpopo National Park / Gaza-Kruger-Gonarhezou Transfrontier Conservation Area to the edge of the reservoir, and the emergence of two other private wildlife concessions aimed to provide eco-tourism facilities close by. A small lodge owned by one of the local communities has emerged to capture tourism of local cultural and environmental assets. The creation of the dam resulted in the construction of an all-weather surfaced road that links Massingir with the provincial capital and Maputo. This has also promoted its regular use for traders in maize, fish and charcoal. The fishing which was initially a small scale activity has risen to become a profitable source of income with local associations formed to reap the benefits in a more organised fashion. When the dam rehabilitation with the added production of hydro-power is completed, the multipurpose use of the dam would bring even greater potential for the economic development of the area.

Source: G. Thompson. The Local Vulnerability Study. World Bank unpublished report, 2004 improving livelihoods of rural populations. Experiences with small and medium size dams demonstrate that they contribute significantly to rural poverty reduction through increasing agricultural productivity and improving household food security, diversifying local economies and improving local incomes (Box 3.3).

Before Independence, 40 small reservoirs for various purposes (urban water supply, irrigation, cattle, small industries) were built in the Incomati and Umbeluzi basins. About 40% of these dams are still in operation although most of them need rehabilitation. In 1975 it was reported that there were 600 dams in Mozambique, but currently due to the civil war, neglect and lack of maintenance only 50 are thought to be functional.

One of the priorities for the Government is the rehabilitation and construction of small/medium size dams to support the country's rural development objectives and, specifically, development of smallholder irrigation and larger commercial schemes as means to increase agricultural production in the rainfed areas and improve food security. Costs of irrigation development in Mozambique are very high, making smallholder irrigation unprofitable[xxxi] and commercial value crop-oriented schemes are very sensitive to the level of irrigation development costs. Smallholder irrigation projects are currently financed by foreign aid programs, however these subsidies are likely to decrease. Therefore future development of smallholder as well as larger private irrigation schemes will depend on improved returns to investment in irrigation. In this regard, it is becoming critically important to ensure multi-purpose planning and design of the smaller storage infrastructure, which would provide reliable water supplies to irrigation but also to rural and small town WSS systems, small scale hydropower, fisheries, transportation, etc. This would ensure higher returns to the storage infrastructure investments as well as allow for effective cost-sharing of the investment costs among the beneficiaries.

The impact of the storage cost sharing on irrigation investment returns was assessed using a modified simulation model developed in the recent World Bank water resources study for the Zambezi basin[xxxii]. Simulations were run based on the assumptions that (i) an average cost of a dam construction/rehabilitation is US$570,000[xxxiii]; (ii) the average irrigation development costs for smallholder schemes are US$4,750/ha and for larger commercial private schemes - US$7,400/ha; and (iii) the dam construction costs are fully allocated to the irrigation development. The simulation results have shown that only smallholder schemes with the area of 125 ha or larger are economically viable (EIRR of 10% or more). No large/medium private irrigation farms are viable despite the fact that they benefit from higher irrigation value added than the smallholders (Figure 3.8). However, when costs of storage development are shared equally between irrigation and other users, smallholder schemes of 75 ha or larger and medium/large private farms of 150 ha or larger appear to be viable (Figure 3.9). If the irrigation users have to cover 70% of the storage costs, economically viable size of the smallholder schemes should be at least 100 ha.

International experience[xxxiv] suggests that to fully utilize potential benefits of small/medium dams, it is necessary to use a programmatic approach to their development planning and to closely link small dam projects to national or regional/local socio-economic development programs and plans.

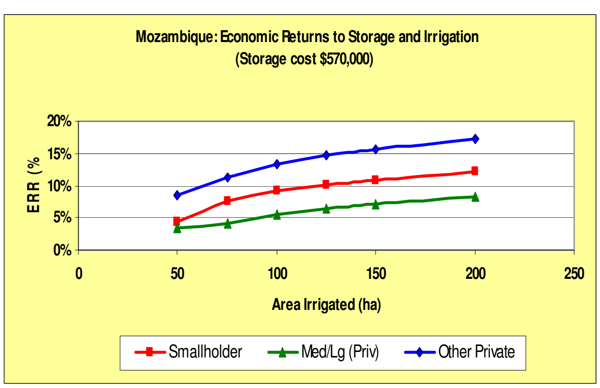


Figure 3.8 Economic returns for single-purpose irrigation storage

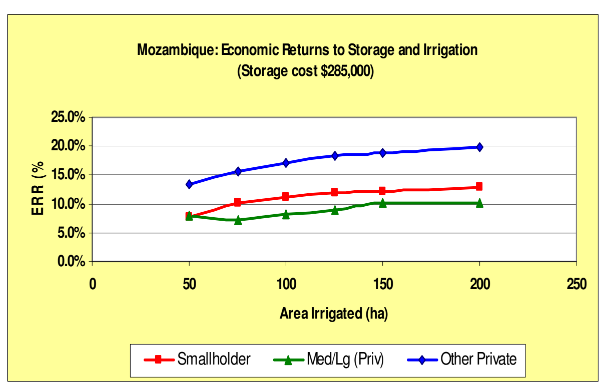


Figure 3.9 Economic returns for multi-purpose irrigation storage

4.5 The Response - Small Scale Water Resources Development

Community-based sustainable management and development of water resources of small streams, groundwater resources, and local watersheds in the poorest areas as well as construction of small hydraulic structures and local scale hydropower units, water harvesting and development of small- holder irrigation, flood protection and water quality protection all contribute to the sustainability of local livelihoods.

Special attention needs to be given to WSS for *small rural towns*. Since the mid 1990s, most of the emphasis for the development of infrastructure has understandably been on the regional urban centers, including water supply and the road network linking them. At the other end of the scale, there has also been progress in rural water supply and sanitation, generally serving small rural communities in the 250 to 500 population range, but not at the scale of the small towns. Most of the small town infrastructure and the road network that did exist were destroyed or decayed during the years of conflict. A functioning network of small urban centers is important for the development of agriculture (as market centers and pre- and post-production services), for social services such as health and education, for financial services, and for effective decentralized governance. Infrastructure, including water supply, sanitation, electrification, telecommunications, and feeder roads are important requirements for these services to work well. The draft Rural WSS Strategy identifies Nampula, Zambezia, Sofala and Gaza as priority provinces for the program implementation.

In the Centre and Northern regions, water resources development priorities include provision of water supply for existing and potential irrigated areas in the Buzi, Pungwe, Zambezi and Lurio river basins. While rainfall in these regions is higher and more stable than in the South of the country, localized hydrological droughts are very common in some areas. Construction of small and medium dams would guarantee reliable water supply for the existing irrigation schemes as well as new irrigation perimeters.

4.6 The Response – Institutions: Is the Water Resources Sector Up to the Challenge?

4.6.1 Framework of Water Policies and Strategies

The National Water Policy (NWP) was approved by the Government in August 1995. The approval of the Water Policy followed the Water Law of 1991 and appeared at a historical moment, after the Peace Agreement in 1993 and the first multi-party general elections in October 1993.

In 1995, the priority of the Government, after many years of civil war and with an impoverished population, was to restore basic services, particularly water supply in urban, peri-urban and rural areas. There was also a need to introduce new actors into the water sector, particularly private operators, and develop new approaches for the provision of water services.

Since 1995, a number of achievements have been made in the water and sanitation sector. The NWP committed the government to decentralization, with increased autonomy and financially self-sustaining provision of water supply and sanitation services. In the urban water supply sub-sector, a new legal framework for delegated management and regulation was created. In the rural areas, a demand responsive approach was introduced for the development of new water systems aimed at ensuring greater sustainability. This experience, initiated on a pilot basis, proved to be successful and is now expanding to all regions of the country. Public Private Partnerships (PPP) were progressively promoted while stakeholder and public participation was endorsed as an important factor for sustainable water management.

In spite of the successes that have been achieved since 1995, the Government has recognized that the priority given to the provision of basic water services resulted in insufficient resources and attention being dedicated to water resources management issues. Water management requires a high priority in the national development agenda, given the dependence of the country's social well-being and its economy on water within the context of limited national water endowments and high hydrological variability.

Over the last several years, the DNA has undertaken a number of studies to analyze water resources management problems and to create a "portfolio" of potential water infrastructure projects. The IDA-financed NWDP I and NWDP II contributed to a process of revision of the National Water Policy and the development a National Water Management Strategy (NWMS). The Strategy identifies objectives for the water management sector and provides broad guidelines for achieving those objectives through water development activities and projects. The Strategy comprises a comprehensive portfolio of water resources management projects and plans in such areas as water resources development; water resources assessment; monitoring; river basin management; flood risk analysis and disaster management; international rivers; establishment and further strengthening of regional water administration entities (ARAs); administration of water law, water policy, regulations and utilization; institutional strengthening and capacity building.

The NWMS needs further prioritization of water resources interventions in the context of PARPAII and national growth strategies, providing detailed and economically justified guidance on potential investments in water resources in the short- and medium term.

4.6.2 The role and status of the DNA

In the early 1990s, the water sector was highly centralized with all planning, implementation and operational responsibilities and functions at the central level represented by the National Directorate for Water (DNA). Since then, the sector has implemented comprehensive decentralization reforms by devolving most urban water supply functions through the establishment of FIPAG and the urban water supply regulator, CRA, and progressively setting up ARAs as regional river basin management authorities.

This process continues with DNA currently assuming responsibilities at the national level for policy, planning, sector oversight, and some remaining small water supply and sanitation services pending further decentralization. At the regional level the five Regional Water Administrations (ARAs) are responsible for water resources development and management. They have administrative, organizational and financial autonomy but report to the DNA. The ARAs are also responsible for collecting hydrological information. They control the irrigation systems and collect water fees. The only ARA currently fully operational is ARA-Sul (South). ARA-Sul is responsible for the southern part of the country up to the Save River. In areas not yet covered by an ARA, the Provincial Directorates of Public Works and Housing are the authority responsible for water resources management in the province. The National Water Council (CNA) was created in 1991 as a consultative body to the Council of Ministers. In general, however, the CNA has not been very effective and coordination between agencies involved in water resources management has been a constant source of concern.

The major constraints as regards institutional capacity have been a lack of strong leadership in the sector and the early stage of establishment of ARAs (other than ARA-Sul). Strengthening of the DNA's capacity is required to help it take a proper role in providing sector leadership, including preparing and planning sector development, building sector capacity, and more effectively asserting its role in donor coordination and international cooperation over transboundary river basins.

Strong leadership in the sector assumes not only strengthening the capacity of the DNA but also elevating its institutional authority. The establishment of water agencies that are more at arms-length from the government (ARAs, FIPAG) has been effective in creating capacity and removing the constraints against decentralization in water management. However, in the creation of the ARAs and FIPAG, no provision was made to ensure that the DNA retained significant powers in the sector as a policy making and strategic planning institution and that it has authority to ensure that government policies and strategies on water resources are followed and their implementation is monitored. Other water institutions (eg the ARAs and FIPAG) have pay scales and benefits which are independent of the government public service constraints - this results in the DNA, which should be the lead agency in the sector, being regarded as having a lower status than the other institutions and being less prestigious from a career perspective. The DNA consequently finds it difficult to recruit staff and suffers from a capacity problem which is detrimental to the sector as a whole.

The DNA has prepared a proposal to remedy these deficiencies which is currently under discussion in the government. Specifically, it proposes to transform the DNA into a National Water Authority (ANA) - a parastatal institution with a greater degree of business independence and flexibility within the same Ministry of Public Works and Housing. To bring helpful and progressive change to the water sector, it is necessary to "rebuild" the DNA as a strong and capacitated institution in terms of its identity, stature, role and its technical and managerial leadership.

In terms of the regional water authorities, ARA-Centro is already functioning but needs continuing support, and ARA-Zambezi is newly established. SIDA is supporting ARA-Centro with a comprehensive on-going program of assistance. The EU's support of ARA-Zambezi is scheduled to end in December 2007, and other sources of support will be required. ARA-Centro-Norte and ARA-Norte have not yet been established but donor support for their establishment is being arranged from the AfDB. Capacity building particularly for the three most northern ARAs over the next two years would be an important prerequisite of successful water resources management in the northern basins.

ARA	Mean annual runoff		
	At border (km³)	Generated in Mozambique (km³)	Total (km³)
South	17.0	3.8	20.8
Centre	1.2	18.4	19.6
Zambezi	88.0	18.0	106.0
Centre-North	0.0	35.2	35.2
North	10.0	24.9	34.9
Total	**116.2**	**100.3**	**216.5**

Source: FAO AquaStat - Mozambique

Table 3.1. Responsibility Areas of ARAs

4.6.3 Strengthening Water Resources Planning Capacity

Government involvement is necessary in the development and management of water resources for the following reasons:-

- Due to the public nature of the resource,
- The investment needs for water infrastructure are beyond the resources of private investors, and
- There are significant social and environmental externalities associated with water development and use.

A strong water resources planning function based on credible technical and economic analysis needs be established within the government to ensure that its policies and strategies are implemented in a timely and efficient manner. Sound water investment planning based on national strategic growth objectives would overcome the tendency to allocate funding to projects on the basis of political criteria and short-term expediency, rather than on the basis of economic, social, environmental, financial and institutional feasibility. It would ensure a more comprehensive study of options for meeting the identified demands and would result in more cost-effective investment decisions supported by the analysis of financing opportunities including public-private partnerships. Planning of water resources development should be undertaken in a river basin management context, aiming at increasing the efficiency of water use by the main economic sectors and, at the same time, ensuring environmental sustainability of the basin system.

To carry out the water resources development planning functions, DNA needs to strengthen its capacity in the area of water resources economics, investment planning and analysis, and water resources planning. The present organizational structure of DNA includes such Departments relevant to the function of strategic water resources planning as the Planning Department and Water Resources Department. The organizational structure of the DNA and the departmental functions, responsibilities and modes of inter-departmental cooperation, including data and information exchange, may need to be reviewed in order to establish at DNA an effective strategic economic planning service. The role and responsibilities of ARAs in the water resources development planning would need to be defined as well.

4.6.4 Addressing Transboundary Issues

Inadequate agreements, lack of sufficient monitoring and over abstraction in upstream countries has resulted in the disappearance of low and medium seasonal flows and increased flood risk on important transboundary rivers which flow into Mozambique. This may lead to very serious consequences for Mozambique's future economic growth and social development if no agreements covering basin-wide development and providing transboundary flows in times of drought are reached in the near future with the riparian countries.

Mozambique has been proactive in establishing dialogue with upstream neighbors and achieved certain success in negotiating initial agreements. However, "deeper" agreements that would put caps on the level of consumptive water use in each country and provide an equitable balance of water use between riparian states in each basin, are becoming increasingly necessary. An important prerequisite is that the countries all comply with the spirit and letter of the SADC Protocol and, for issues on the Zambezi, the ZAMCOM agreement on cooperation and data exchange, and that the highest possible scientific and engineering expertise is applied to these issues.

Being a downstream country in 9 international river basins, Mozambique has limited leverage in regard to water resources *per se*, and at present can only call upon the SADC Protocol, other agreements, and its neighbors' sense of fairness, in seeking equity and true sharing of the benefits of the shared waters. However, Mozambique and its neighbors obviously have much more interdependency than the waters of the river basins they share. For example, Mozambique provides valuable transport routes for imports and exports. It exports gas to South Africa, and both imports and exports large quantities of electric power, in which Cahora Bassa plays an important role. With Mphanda Nkuwa and Cahora Bassa North power generation facilities now planned, power interdependencies will continue to increase. Trade and tourism in both directions are increasing. So the economic and social interdependencies are strong and increasing, to the benefit of all, and in some of these areas of interdependency, Mozambique is in strong position relative to its neighbors.

An emerging strategic option for Mozambique is to place the transboundary water issues into the broader context of political and economic relations with riparian countries and integrate water problems into the existing process of international economic negotiations and agreements between the nations. This requires acknowledgement of water as an important strategic resource for the nation at the highest level of the Mozambique Government.

4.6.5 Risk Reduction and Disaster Management

Mozambique is at risk to several forms of natural disaster such as floods, droughts, cyclones and seismic events. Some of these phenomena are cyclical while others are occasional. PARPA II 2006-2009 includes the management of disaster risks as a cross cutting issue thereby recognising the need for a long term plan to reduce the vulnerability of communities and infrastructure exposed to extreme natural phenomena.

A national disaster management law is in draft form, and has been awaiting ratification by parliament for a number of years. As a result the roles and responsibilities of the different government departments in disaster management are not clearly defined. A National Master Plan for Disaster Risk Reduction including disaster management was approved by the Cabinet in March 2006. On the basis of the master plan there is an ongoing process of the formulation of operational plans. To improve disaster preparedness and management at national and local levels, it is necessary to mainstream disaster risk reduction in strategic planning and sectoral development policies, including the water resources sector, and to develop the country's institutional and human capacity to manage disaster risk.

4.6.6 Strategic Support to National Groundwater Exploration

There is little information about groundwater potential in Mozambique, except where there have been special investigations to fulfill needs of certain towns, where surface water sources were not economically available. Groundwater is currently used for some water supplies, including such towns as Pemba, Tete, Xai Xai and Chokwe, and "machongos", wetlands often found at the foot of the eastern escarpments used for dry season farming through careful control of groundwater levels. It is also known that there are some groundwater resources in the sandy coastal plain, although soils there are generally poor. Given the fact that the geology of sizable parts of Mozambique is very similar to that of neighboring countries where groundwater has been found in substantial quantities and plays an important role in the national water supplies[xxxv], thorough investigation of the groundwater potential in Mozambique is an important strategic priority in water resources development. This has already commenced with the in the Maputo Metropolitan Area in the form of the 2007-2010 ARA-SUL Groundwater Resources Pilot Program.

The hostilities that ended in 1993 prevented groundwater exploration in Mozambique in the past. However now, with national priorities changing to positively promote water resources development for small rural communities, it is clearly of strategic importance to initiate a national groundwater exploration program. Such a program should identify and map groundwater occurrence, yields and quality throughout Mozambique, beginning with the provinces and corridors that are (1) likely to be prospective for such groundwater resources, and (2) of high national priority for water resources and community development for domestic water supply and small scale irrigation. In addition, the Government's relevant strategies and policies should require that identification of opportunities for small and medium scale water resources development should always include evaluation of groundwater as well as surface water options.

4.6.7 Water Information and Knowledge

Data and information services are core public functions which are necessary for effective water resources management and regulation in the face of rising demand across sectors, changing social and economic conditions, and scarcity of public investment resources. The current inadequate water resources data and information services make investment decisions on water resources imprecise and subject to a wide range of subjective influences. Hydrologic networks and collection of reliable data on water availability, use and demand, as well as environmental data, were seriously neglected in Mozambique over a long period of time. This has the direct consequence that the analytical basis for making important water resources decisions such as water allocation and investment prioritization, remain weak and may lead to poorly justified, non-optimal and delayed actions.

The development of water resources and environmental information systems is not new to Mozambique, and several systems have been implemented at research institutions as well as government departments. However, the absence of an overall strategy for development of water resources information systems resulted in the establishment of fragmented sub-systems, normally lacking coordination and data sharing mechanisms. There is no lead institution to guide and co-ordinate the development of an integrated system, and implementation has been mostly driven by donor-funded initiatives in response to specific demands. Another deficiency of the existing approaches to water information system is that they focus more on data collection (often based on outdated information technologies) and less on data processing to provide information and complex knowledge products, as well as on information dissemination to the public. To address these issues the development of a water information strategy was proposed as part of the draft NWRMS. Subject to government approval of the NWRMS, the information management strategy would need to be further reviewed and prioritized for staged implementation.

4.7 Investment Implementation Capacity

4.7.1 Implementation Capacity Requirements

The actual scope for investment interventions is defined by the economic needs for water resources development, the availability of financial resources, and, importantly, by the capacity of the Government to implement the investments and ensure their long-term sustainability.

While donor support to the water sector in Mozambique has increased dramatically over the last years, the capacity of Mozambique's water resources management and development institutions to implement donor supported projects and programs remains very limited. The factors affecting the implementation capacity include :-

1. GOM's financial capacity to support a portfolio of water resources development and management projects. This includes the capacity of GOM to produce its counterpart funding commitments in a timely way, and the efficiency and effectiveness of the systems of budgeting, accounting, payment, and auditing;
2. Capacity of the implementing institutions to meet the requirements of the projects in terms of a strong presence in the localities of the project which are often in remote locations;
3. Capacities to assemble and support project implementation teams with the range of expertise needed (project management, procurement, engineering supervision etc); and

4. Technical and financial capacity to support sustainable operation and maintenance of the infrastructure upon project completion.

Implementation of water infrastructure projects imposes high demands on staff and requires the right mix of skills and expertise in the implementing units. The Mozambique water sector has learned lessons from experiences with NWDP I and II, and is applying them in the design of projects supported by different donors. The main recommendation is to ensure that project selection takes into account the full work load faced by implementing units including the load from each unit's non-Bank project commitments, and avoids an excessively wide variety of projects which cannot be packaged together for procurement and supervision. Multi-sectoral projects combining energy and/or agricultural components may be a special challenge, as each component will require supervision from the concerned Ministry to an extent that is commensurate with the commitment of the others.

4.7.2 Government Financial capacity

Water programs have been traditionally regarded in Mozambique as having a lower profile and importance to the national development compared with many other economic sectors. As a result, the sector remains chronically under funded and DNA has a very low institutional status in the government. In addition, the almost non-existent recovery of O&M costs[xxxvi] in the water resources sector poses a concern regarding investment sustainability.

The PARPA II clearly acknowledges the importance of water infrastructure development as an essential factor for the rapid expansion of economic activities and for the reduction of poverty. It states[xxxvii] that "public services and the infrastructure necessary to achieve comprehensive and well-balanced economic growth should receive more attention and more funding in the coming years. Heavy investment in social welfare in the past has contributed to relatively small appropriations for infrastructure…".

As indicated in the PARPA II, in the period from 2006-2010 the water sector including water resources management and water supply services will receive on average 5.6% of the annual budget allocation, up from 2.5% in the period of 2001-2005 (excluding donor funds). The allocation of this budget within the water sector over the period 2006-2010 is as shown in Figure 3.10.

Traditionally, the Government assumes responsibilities for financing water resources development and management. Clearly, while the government budget for the water sector has increased, these planned expenditures are still too small to meet the challenges imposed on the national economy by water-related vulnerability. The most promising sources for financing the shortfall in the requirements for improving water infrastructure and water management would be expanded external government borrowing for water development projects, donor assistance to complement government efforts in improving water resources management, and, if actively solicited, private investments. The National Water Resources Management Strategy sets up principles for encouraging private sector participation in investing in water management projects. It emphasizes the importance of adequate water use charges to recover costs of improvements in water management services and operation and maintenance of existing infrastructure.

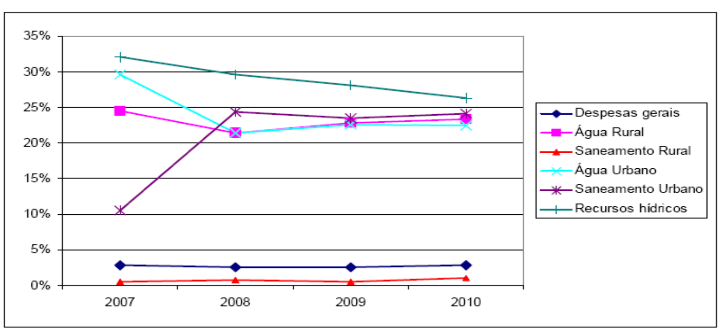


Figure 3.10. Budget allocation within the water sector in 2007-2010

5 The Role of the World Bank

5.1 What the Bank has done in the past

The history of the Bank's partnership with Mozambique dates back to 1984 when a first assistance program with a focus on post-war reconstruction was approved to help the country with rehabilitation, structural adjustment and economic sector development. After that the Bank's assistance followed a comprehensive country support strategy in the early 1990s, and the recent assistance strategy of 2000-2005 to support implementation of the Government's five-year program on poverty reduction (PARPA) in the areas of enhancing economic opportunities, governance and empowerment, and human capital. The new Country Partnership Strategy (CPS) for 2008-2011 was finalized in April 2007. Its purpose is to support the Government of Mozambique in implementing its second Poverty Reduction Support Strategy (PARPA II) and promote growth and pro-poor service delivery, strengthening governance and accountability, rural development and infrastructure.

In April 1998 Mozambique was the sixth country in the world to be declared eligible for debt relief under the World Bank and IMF Heavily Indebted Poor Country (HIPC) Initiative, ensuring some US$1.4 billion in debt relief.

As of April 2006, the World Bank had approved 54 projects for Mozambique totaling approximately US$ 3 billion. The Mozambique portfolio currently has 19 active projects in all major sectors with a commitment value of about US$ 950 million.

The first substantial growth and development in water resources management capacity came with the National Water Development Project I (1998 to 2003) supported by the World Bank with co-financing from four bilateral aid agencies. Its main objectives were:

- to reorient and strengthen the country's water sector institutions,
- to prepare for private sector management of water supply in five cities,
- to reorient and reform the rural water supply and sanitation sector, and
- to improve the management of Mozambique's water resources.

The efficacy of the project in achieving these objectives was rated as substantial to high.

The NWDPI also provided support to strengthening of ARA-Sul, while ARA-Central based in Beira and with the responsibility to oversee the Pungué, Buzi and Savé basins was established with support from SIDA. More recently, ARA-Zambesi was also established, with support from the European Commission. The Africa Development Bank has undertaken to support the establishment of ARA-Norte.

One of the objectives of the Bank's water resources management support to Mozambique was also to provide assistance with transboundary water resources management issues. The Office of International Rivers was established in the DNA and was active throughout this period in seeking to protect Mozambique's interests in the eight transboundary rivers where it is the downstream riparian. The role of the Bank in transboundary water resources was not to support the gaining of relative advantage by any one country. Instead, the Bank responded to requests to strengthen the capacities of the weakest, so that a more level playing field is created, outcomes are more likely to be fair, and development can result in win-win solutions.

The National Water Development Project II was launched in 1999. Through this second World Bank supported project in the water sector, Mozambique has put in place private sector management of the water supply systems of Maputo and four regional cities. The Government established FIPAG (Fund for Water Supply Investment and Assets) as the agency responsible for major urban water supply. It also set up a regulating authority, CRA (Council for the Regulation of Water Supply). More recently, the Government has sought to improve water supply services in four large towns in the south by adding them to FIPAG's portfolio. A further such step covering several towns in the central provinces is also getting under way. The project also supported preparation of the National Water Resources Management Strategy, which provided a comprehensive analysis of the water management issues in the country and outlined the sector investment needs in the short, medium, and long term.

The Bank's involvement in water resources management, development and service provision, has therefore been a partnership with Mozambique that has supported and led to a number of important achievements:

- The formulation and implementation of institutional arrangements for water resources management and the provision of urban water services. The institutional structure is now widely regarded as exemplary.
- The introduction of a community driven model for the provision rural water and sanitation services, adopted now throughout the country. This has resulted in much greater sustainability and service value;
- Major upgrades in the quality and financial sustainability of urban water supply services, in all of the cities now managed under FIPAG. This has set a strong foundation for future growth and improvement in water supply. The strength of FIPAG and the private sector management arrangements for Maputo has attracted substantial further support from the donor community. This appears likely to lead to increases in water supply coverage for Maputo and Matola that should meet the relevant Millennium Development Goals.
- Making Corumana dam safe and operational, so that the next step may now be taken to develop the water resources of the Incomati River basin to secure adequate supplies to meet Maputo's growing demand for water, and increasing demands for water for irrigation.
- Development of the National Water Management Strategy;
- Strengthening the system of decentralized water resources management bodies, whose role is to:
  - develop and manage water resources,
  - operate reservoirs,
  - ensure that users' water allocations are secure, and
  - gather hydrological information to enable the planning of further development.
- A stronger DNA, better equipped to exercise sector leadership and to seek to protect Mozambique's interests in transboundary water resources.

The other related on-going and completed projects financed by the Bank in Mozambique include:

- Flood Emergency Recovery Project (2000)
- Post Flood Water Resources Management (2001)
- Market Smallholder Development in the Zambezi Valley (2006)
- Water Services and Institutional Support (2007)

Note that the activities identified are priority areas where investments are required and not necessarily activities in which the World Bank itself would be directly engaged. Figures given are broad estimates of the costs of the suggested areas of investment.

5.2 Priority investment areas for the period 2008-2011

The objective of this CWRAS is to assist in the analysis of Mozambique's water resource investment and management options, and to determine where the World Bank would be best able to assist the Government in the achievement of its growth and poverty reduction objectives in the water sector and in those sectors which depend upon water. The CWRAS will assist the Government in choosing water sector activities for the Bank's engagement in the next 3-5 years. The CWRAS is consistent with the Bank's CPS and complement the on-going international support in the water sector provided by other donors.

The Bank has a strong interest in continuing to support the Mozambique water sector due to the multi-sectoral scope of the assistance required, the ability of the Bank to forge cross-sectoral cooperation, the unique experience that the Bank has in institutional capacity building, and its substantial expertise in the areas of water resources management, transboundary issues, community-driven approaches, and policy and institutional reforms.

As described in Chapter 3, this Strategy identifies such broad areas for priority water resources investments as

(i) development of additional water storage in the Incomati, Zambezi, and Pungue basins; (ii) development of small and medium dams to support the country's rural economy; (iii) support to small scale water resources development; and (iv) assistance to the Government with institutional capacity building in the water resources sector.

The prioritized areas of investment as identified through the CWRAS for the period 2008-2011are as indicated below.

A. Water resources development and management in the Incomati and Umbeluzi basins. The proposed interventions would include:
(i) *Completion of Corumana* Dam as the least cost augmentation of water supply to Maputo which would include construction of a water treatment plant and transmission pipeline to Maputo - estimate: Stage 1-$81m;

(ii) *Construction of Ressano Garcia weir* to monitor transboundary water flows, including a small treatment plant and a distribution system for the town - total cost estimate: $4 million;

(iii) *Support to institutional strengthening of ARA-Sul*, including introduction of a new tariff system for water users to ensure the sustainability of operation and maintenance of the water resources infrastructure.

B. Small scale water resources development. This component would include:
(i) Construction of *small and medium multi-purpose dams* for Nampula, Nacala and Quelimane in the Northern Mozambique - total cost estimate: $60 million;

(ii) *Community-based sustainable management and development of water resources of small streams, groundwater resources, and local watersheds in the poorest areas* (for example, in Nampula Province). The possible activities could include construction of small hydraulic structures and local scale hydropower units, water harvesting and development of small- holder irrigation, flood protection and water resources protection against polluting activities;

(iii) *Support to smallholder irrigation*. Principles for selecting provinces or regions to commence such a program include (a) preference for areas which have the largest numbers and concentrations of poor smallholder farming families, thus giving the greatest immediate impact on food-security and poverty (b) the presence of a network of rivers and streams that provide sites with access to water and suitable soils and topography for smallholder irrigation; (c) proximity to long term opportunities for larger irrigation schemes that will include smallholders, so that an "irrigation culture" evolves to make possible further steps towards the long term irrigation vision.

(iv) *Water infrastructure for small towns*. Very few small towns have functioning piped water supplies, organized sanitation, or electrification. Well functioning small rural towns are important prerequisites for small farmers who use irrigation, because such farms have greater needs for supplies, markets, milling etc. Through the development of small scale water sources, water can be supplied economically for small town water supplies, and small hydropower plants for electrification of towns which the power grid has not yet reached. Such developments can have a third purpose of providing water for smallholder irrigation.

The Bank has a history of experience in supporting countries in Eastern and Southern Africa in small town water supply programs. Relevant projects completed recently include the Malawi National Water Development Project (which included the establishment of an institutional model very similar to that proposed by Mozambique) and the Zambia Copperbelt Town Water Supply Project. Both of these projects were rated as satisfactory. The Bank is well equipped to support this aspect of water services.

C. Transboundary water agreements. Support to further strengthening of the Incomati, Maputo and Umbeluzi basin agreements between Mozambique, South Africa and Swaziland. This would be to secure future water use rights, particularly with regards to the possible future construction of Moamba Major, for sharing the water shortages during droughts and the joint implementation of flood warning systems;

D. Sustainable water resources management for economic growth and poverty reduction in the Zambezi basin. This, specifically, includes:

(i) *Support to the possible development of the Mphanda Nkuwa and Cahora Bassa North water re-*

sources projects. This would primarily be to provide investor confidence and to ensure that multiple benefits, including environmental assets are maximized. See Section 4.4.3 "Additional Infrastructure on the Zambezi".

(ii) Analysis of Zambezi basin multi-sector investment opportunities. This is an existing study which will provide the analytical foundations to both assist the Bank in defining a long-term support strategy for investments within the basin as a whole and riparian countries, and contribute to the processes being undertaken by the riparian states of the Zambezi Basin. Improved management and cooperative development of the Zambezi River basin has the potential to significantly increase agricultural yields, hydro-power outputs and economic opportunities. Collaboration has the potential to increase the efficiency of water use, strengthen environmental sustainability, improve the regulation of the demands made on natural resources, and enable greater mitigation of the impacts of droughts and floods. Seen in this light, cooperative river basin development and management provides a potential platform for regional economic growth, cooperation and stability within the wider SADC.

E. Support in Water Supply and Sanitation. Support to institutional development and capacity building, including: financing the management contracts for Beira, Quelimane, Nampula and Pemba; studies/assessments: beneficiary assessments; assessment of financial, viability of new services; tariff studies; human resources development / training programs in water utilities operations.

F. Policy development in the water and irrigation sectors. The principal objective of this assistance would be to support GoM in further development of an appropriate set of policies and instruments to strengthen water resources planning and development in the country and to improve co-ordination of the water user agencies within the framework of integrated water resources management. This would also include support to better coordination between the water and agricultural ministries in developing an integrated approach to irrigation sector development, aiming at increased resilience of farmers to droughts, food security and alleviation of rural poverty.

G. Institutional building in the water sector. Water sector institutions require strengthening to improve efficiency of the sector institutions; enhance the DNA's capacity as a leading national water resources planning and management organization; further support the establishment of ARAs as technically and financially sustainable river basin agencies and ensure closer coordination and synergies among the ARAs, and between the ARAs and DNA; the completion of Basin Master Studies; and promotion of stakeholder involvement in water resources management at the national, regional and local levels.

H. Risk Reduction and Disaster Management. The World Bank, together with other partners, especially in the UN system, is engaged already in a substantial technical assistance program to the Government of Mozambique in Disaster Risk Reduction of which the objectives are to (i) mainstream disaster risk reduction in strategic planning and sectoral development policies; (ii) support the government to develop its institutional and human capacity to manage disaster risk, (iii) provide specific support to strategic activities to enhance preparedness at national and district level; and (iv) facilitate the best application of World Bank Group experience and knowledge to disaster risk management for the short and long term within the context of country economic analysis and sectoral growth strategies.

5.3 Financing the Proposed Assistance

5.3.1 IDA support

The Bank's notional allocation for Mozambique for the period FY2008-11 is similar to the allocation of the previous CAS period of $650 million over four years. But as the actual IDA allocation is performance-based, the amount of financing will be significantly influenced by Government performance. Assuming progress under the performance framework relative to other IDA beneficiaries, the annual financing available to Mozambique is expected to remain at approximately $155 million over the FY2008-11 period. Many of the priority areas noted above represent water related issues within a variety of different sectors such as agriculture, water supply, energy etc and would form part of sectoral projects and proposals either currently active or which will be part of investment preparations in different sectors during the FY2008 - 2011 period.

At present, the IDA budget of about $20 million is tentatively allocated for a water resources operation for FY09. Financing of the priority areas noted above, in particular addressing the need for the next strategic augmentation of Maputo's bulk water needs, support to securing international water rights, institution building in the sector, and support to the implementation of the the etc. will require the involvement and cooperation of a number of partners which may lend itself to a programmatic, sector-wide approach for water resources in the country. The details would be determined through an intense project identification process to confirm the needs of the Government.

5.3.2 Private sector participation

Financing of large hydraulic structures is likely to remain in the government domain. However, private sector participation in such investments is possible for multi-purpose projects with revenue creating components, such as hydropower production, commercial irrigation and urban water supply functions, combined with non-revenue functions such as flood control.

Community participation in construction and rehabilitation of small dams and reservoirs, and local flood protection facilities, could be facilitated through labor-for-food and other labor-based community programs.

5.3.3 Development Partner Involvement

The proposed priority assistance program would be implemented in close partnership with international donors active in the Mozambique water sector. Despite recent encouraging economic growth rates, Mozambique remains dependent upon foreign assistance for much of its annual budget. Half of Mozambique's budget expenditures are financed through development assistance, and, since 1992, Mozambique has received increasing support from a number of foreign bilateral and multilateral donors such as World Bank, AfDB, IMF, EU, SIDA, SDC, DANIDA, the Netherlands, Millennium Challenge Corporation (MCC, USA) etc. About 90% of the sector investment budget is financed by donors. At present, the most active donors in the sector are SIDA (a five year technical assistance program in the Pungue basin will be launched this year), The Netherlands, African Development Bank, EU and Swiss Development Cooperation, and the Millennium Challenge Corporation (MCC, USA).

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[i] PARPA II (IMF Translation dated from June 25, 2006): Chapters 1, 8
[ii] PARPA II (IMF Translation), Chapter 1, p. 34
[iii] Excluding the Save river where water demand in Mozambique is very low.
[iv] Predictions based on existing models suggest that changes in the global climate could alter spatial and temporal distribution of water along with the intensity of rainfall events. A 10% reduction in rainfall for Sub-Saharan Africa may result in 20% reduction in the density of perennial drainages. Such changes need to be integrated in long-term infrastructure and economic planning in support of sustainable water resources management.
[v] M. Benito-Spinetto, P. Moll. CEM Background Paper "Macroeconomic Developments, Economic Growth and Consequences for Poverty". World Bank, Africa Region, PREM 1. December 2004
[vi] "The Role of Water in the Mozambique Economy". World Bank Memorandum, 2005

[vii] Arndt C., H.Tarp, S. Robinson. Marketing Margins and Agricultural Technology in Mozambique. IFPRI, Washington DC, July 1999
[viii] Mozambique CEM: World Bank, 2004
[ix] Including all cities and small towns
[x] Finney and Kleemeier. Mozambique Public Expenditure Review. Background paper on the Water Sector. May 2003
[xi] NWDP1: BB4 – Water Resources Development. Phase 1 report, August 2004
[xii] NWDP1: BB4 – Water Resources Development. Phase 1 report, August 2004
[xiii] Mozambique CEM: World Bank, 2004, p. 26
[xiv] PARPA II (IMF Translation dated from June 25, 2006), p.112
[xv] Mozambique Agricultural Sector Expenditure Review – Background paper, World Bank, 2002; and Mozambique: Agriculture Sector Memorandum, World Bank, 1997 Report 16529-MZ
[xvi] Sometimes, the policies to promote large and medium scale commercial farming could be considered as "anti-poor". However, the experience with irrigation projects in Northern Brazil demonstrated that an apparently anti-poor change in policy (auctioning off 50% of new areas to commercial farmers) resulted in a growth-stimulating and poverty-reducing cycle. Poor farmers benefited from such opportunities as becoming sub-contractors to commercial farmers and also from funding employment in the grown up input supply and processing industries in the now-dynamic agricultural sector (World Bank, 2003).

[xvii] World Bank "Mozambique Agricultural Development Strategy - Stimulating Smallholder Agricultural Growth" February, 2006
[xviii] Contribution to CAS discussions. World Bank, Mozambique Rural Development Team: December 2006
[xix] "Is Africa on Target to Meet the Millennium Development Goals on Water Supply and Sanitation?" A Status Overview of the 16 African Countries (draft): WSP, May 2006

[xx] For example, at present, unaccounted for water in Maputo water supply is about 60%, out which at least 30% are attributed to physical water losses in the delivery and distribution systems.
[xxi] Dollar D and A. Kraay. 2001. "Growth is Good for the Poor". "World Bank Policy Research Working Paper 2587. Washington DC
[xxii] World Bank, Mozambique: Growth Performance and Reform Agenda, Africa Region Report No 20601-MZ, June 2000

[xxiii] World Bank. China Water Resources Assistance Strategy, 2002
[xxiv] D.Grey, C. Sadoff " Water for Growth and Development": A Theme Document of the 4th World Water Forum. 2006
[xxv] D.Grey. "The World Bank and Water Resources: Management and Development". Presentation at World Bank Water Week 2004.
[xxvi] Is Africa on target to meet the MDGs on water supply and sanitation? A status overview of 16 countries. Draft for discussion: WSP, May 2006
[xxvii] M. Benito-Spinetto, P. Moll. CEM Background Paper "Macroeconomic Developments, Economic Growth and Consequences for Poverty". World Bank, Africa Region, PREM 1. December 2004
[xxviii] The regression analysis suggests that in Mozambique GDP growth is cut by 5.6% in average when a major water shock occurs. Assuming the rate of the major disaster occurrence as one in five years, on average GDP growth in Mozambique is reduced by 1.1% annually due to the impacts of water shocks (Figure 2.2). This regression model was used to assess the impact of a mitigation scenario on the annual growth rate. Assuming that the necessary water security level translates into full mitigation of water shocks of the small and medium scale and 50% mitigation of water disaster events, investments to reach this level of water security would reduce the annual loss of GDP growth due to water shocks to 0.3%. Thus, the benefit of the mitigation measures is the annual losses of GDP growth of 0.8% avoided, with a Net Present Value of the mitigation benefit of about USD 2 billion. For the mitigation investments to be viable, the benefit-cost ratio should be of 1 or greater. Therefore, given that the present value of USD 2 billion translates into the annual investment equivalent of USD 270 million over the period of 2007- 2020, the viable total costs of achieving the defined level of security in Mozambique against vulnerability to water shocks by 2020 need to be under USD 3.9 billion (or should not exceed USD 205 per capita).

[xxix] DNA (Ministry for Public Works and Housing of Mozambique). National Water Resources Development Strategy. Draft from July 2006
[xxx] " Development of the Pungwe River Basin: Joint Integrated Water Resources Management Strategy": SWECO, August 2003
[xxxi] According to the AfDB Small Scale Irrigation Rehabilitation Project the costs are ranging from US$3000/ha to US$10000

[xxxii] Zambezi River Basin: Sustainable Water Resources Development for Irrigated Agriculture. Draft Report. World Bank, AFTS1, December 2005

[xxxiii] NEPAD-FAO BIPP, Small Dams Rehabilitation and Construction Project, TCP/MOZ.2905 (I), November 2004. The programme for rehabilitation/construction of 50 small dams was developed under NEPAD-CAADP with the total costs ofUS$28.5 million.

[xxxiv] The Impact of Small Dams on Poverty Reduction: A Review of the International Experience: World Bank, 2005, 158 p.

[xxxv] For example, parts of Tete and Niassa provinces consist of the same deeply weathered basement rocks of the southern African plateau that are the source of domestic water supplies for small rural communities throughout Malawi and in parts of Zambia, Zimbabwe, and Tanzania. Alluvium deposits underlying the courses of ephemeral streams can provide a more reliable and safer water supply for domestic and small scale irrigation purposes than stream flows, which in many cases are not available in the dry season.

[xxxvi] The current rate of cost recovery at ARA Sul is about 20%.

[xxxvii] PARPA II: IMF Translation, June 25, 2006. p.46

ANNEX I. Water Resources Assistance in the Bank's CPS 2008-11 (April 24, 2007)

Pillar III - Sustainable and Braod-Based Growth				
Long-term development goals		**CPS goals**		**Instruments**
Government Goals PARPA II	**Key Issues**	**CPS outcomes**	**CPS Milestones:** **Intermediate Indicators (outputs)**	
Ensure fast and sustainable economic growth (PARPA #G.2)	Unsustainable access to water resources for water service sectors: Maputo water supply needs additional water sources starting from 2010-2012 High hydroclimatic variability, limited long-term planning capacity	**Outcome 17: Improved sustainable management of water resources** ➢ Maputo water supply requirements (to 2020) met ➢ Management plan and infrastructure operating rules developed for the lower Zambezi Basin ➢ Increased collaboration with Zambezi Basin riparian countries on water resources management **Outcome 18: Enhanced capacity to respond to disasters** ➢ Early warning and emergency preparedness systems established	➢ Corumana spillway gates constructed ➢ Finance options with other donors packaged and activities identified for investments in development of the Incomati - Umbeluzi basins ➢ CWRAS implemented ➢ DNA restructuring successfully implemented ➢ Cahora Bassa & Nphanda Nkuwa dams assessments completed ➢ Investment framework for hazard prevention, mitigation and preparedness established ➢ Ex-ante disaster recovery financing mechanism established	**New Financing** Water Resources Investment Project **AAA** DNA Capacity Building through the AWRMI Cahora Bassa TA WB Global Facility for Disaster Reduction & Recovery Multi-donor TF: **Current portfolio** Regional ESW: Zambezi Multi-Sector Investment Opportunity Analysis

Mozambique Country Water Resources Assistance Strategy:
Making Water Work for Sustainable Growth and Poverty Reduction

Annex II:

Preliminary Economic Analysis of Maputo Bulk Water Source Development

July, 2007

Preliminary Economic Analysis of Maputo Bulk Water Source Development

July 2007

Africa Water Resources: AFTWR
Africa Region,
World Bank

Contents

I Introduction

The purpose of this paper[1] is to present a preliminary economic and hydrological identification and assessment of possible alternative options of bulk water sources for Maputo. The study includes an assessment of water allocation priorities and the scheduling of investments such as the completion of Corumana dam and the construction of the Moamba Major dam. Support for ensuring the security of the Greater Maputo area's water sources has been identified as a priority intervention for the World Bank assistance in the water sector in Mozambique in the recently completed Country Water Resources Assistance Strategy (CWRAS). This preliminary analysis will contribute to the formal identification process of FY09 World Bank Lending operation - MZ Water Resources Development Project. The generous support provided by the National Directorate for Water, Ministry of Public Works and Housing of the Republic of Mozambique and from ARA Sul in preparing this report is gratefully acknowledged.

The report findings are based on a desk study of available relevant Government materials and feasibility studies, a field visit to the sites of Corumana and Moamba Major dams and on discussions with representatives of the DNA, ARA- Sul, FIPAG, CRA, the Ministry of Agriculture, the Ministry of Energy, the management of Xinavane sugarcane production company, and other relevant agencies and specialists in Mozambique.

[1] Written by World Bank consultants John Shepherd (Water Resources Engineer) and Rimma Dankova (Water Resources Economist), commissioned and edited by Len Abrams, Senior Water Resources Specialist, Africa Water Resources: AFTWR, World Bank.

II Background

The water resources situation in Mozambique is progressively recognized as insecure because of the uneven geographic distribution of water resources across the country and increasing uncertainty in the national water resources base due to the dependence on international river basins, high variations in annual and inter-annual rainfall, frequent droughts and floods, and competing demand by water-dependent economic sectors in some river basins.

The emerging conflicts between growing water demand from the major sectors of the economy and limited water availability in some river basins impose a serious constraint on the medium-term and long-term growth prospects specifically in the economically most developed Southern part of the country. From 2007 to 2028 the domestic and industrial water demand is predicted to more than double in Southern Mozambique. With a steady growth in the large industrial sector, the water demand for large industries was estimated to increase by 70% in the South. For the Greater Maputo area the current consumption is estimated in the order of 70 million m3/year and is projected to double by 2020. It is expected that this water consumption will increase mainly through rapidly growing domestic and commercial demand, and also in response to industrial demands such as Mozal 3 and, possibly, the MISP (Maputo Iron and Steel factory).

To address the emerging shortage of bulk water supply to Maputo, the Government of Mozambique, through its urban water supply asset holding agency, FIPAG, is currently upgrading the water treatment and transmission facilities so that more water from the Pequenos Libombos Reservoir on the Umbeluzi river can be delivered to the city. At the same time, it is implementing measures to reduce physical losses and increase the efficiency of the water delivery system. Nevertheless, as illustrated by Figure 1, by the end of 2011 the yield of the Pequenos Libombos reservoir will be fully utilized to supply Maputo's domestic, commercial and industrial water users.

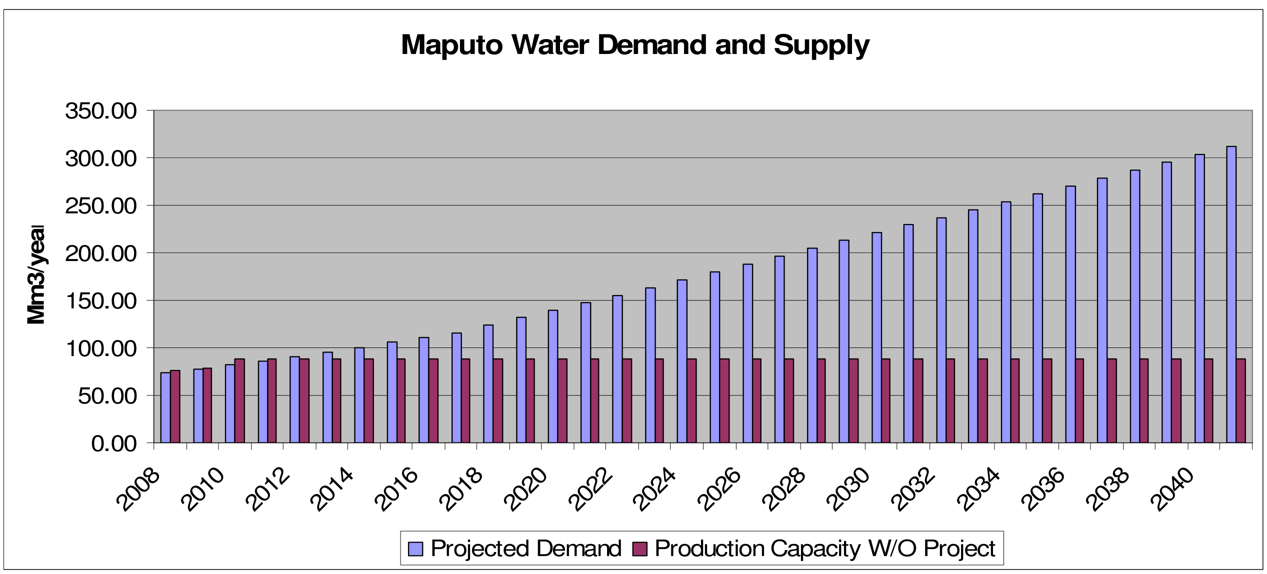

Figure 1. Maputo Water Demand and Supply without Additional Bulk Water Source

With the demand from domestic, commercial and industrial consumers increasing rapidly, a new source of water will therefore be needed by end 2011, if Greater Maputo is to continue to grow and prosper. If an additional source of water is not available by then, shortfalls in supply will occur from then on in years or combinations of years when reservoir inflows are at or below average. Such shortfalls would disrupt economic growth and expose communities to increased risks of waterborne disease. This clearly shows the urgency to develop an alternative water source for supply to the Greater Maputo Area. Water requirements at this scale cannot be met from small local intakes or reservoirs and, therefore, substantial scale infrastructure solutions are required in the Incomati river basin.

III Options for Additional Bulk Water Supply to Maputo

Stage I Increment of Supply

A number of studies undertaken by the Government to identify and assess possibilities to increase bulk water supply to Maputo resulted in identification and assessment of the following two main water resources development options, both located in the Incomati basin:

(a) to complete Corumana Dam on the Sabie river, a tributary of the Incomati River, by installing the spillway gates for which it was designed (plus some other minor works), and build a pipeline to Maputo from the Incomati River at the Sabie River confluence, and a water treatment works; or

(b) to build the proposed Moamba Major Dam on the Incomati River, a pipeline from near Moamba to Maputo, and a water treatment works.

The largest of these two options in terms of both yield and cost is the proposed Moamba Major Reservoir. This option is the one which appears most frequently in national strategic development documents.

It is estimated that the Corumana option, with a first stage pipeline and treatment plant, has an estimated cost of about USD 81 million (all estimates are in 2006 values), and could be delivering water by the end of calendar year 2012. The installation of the spillway gates and other works at the dam would cost about USD 27 million, and the rest is for the pipeline and treatment works. The Moamba Major option with a first stage pipeline and treatment plant and a small hydropower station would cost an estimated USD 291 million, or $24 million less if the proposed small power station was delayed.

However, the comparison of the Maputo water demand projections[2] and the yield available from the Pequenos Libombos reservoir demonstrates that this yield will be fully utilized to supply domestic, commercial and industrial water users in the next 3-4 years and a new source of water for Maputo will therefore be needed by the end of 2011 (see Figure 1). For that reason, the Moamba Major Dam is not a viable option to meet the Maputo water demand of 2012. Even if the financial resources for the Moamba Major become available immediately, the soonest it could deliver water to Maputo is by the end of 2016 (including design, construction and a two year period for the dam to partially fill). Exposing greater Maputo to a period of under-supply of 5 years or more during the Moamba Major construction would be unacceptable.

Therefore, the economics and cost structures suggest that to meet the upcoming shortage of water for Maputo by 2012, ***the completion of Corumana Dam is the necessary and immediate investment to be implemented as the first stage of increment supply to Maputo.*** The Corumana Dam raising option would present only a small risk of shortfall, if it cannot be completed as expected until some time in 2012. This project should be commenced and completed as soon as possible.

[2] Maputo water demand projections provided by FIPAG are based on the longer-term needs of the Greater Maputo area, including the habitational expansion areas towards the currently rural areas of the Matola Municipality (all bairros from Matola-Gare at the West, Kongolote at East and up to Mucatine at the northern tip), and the neighboring districts of Moamba and Marracuene (including the villages of Moamba and Marracuene). For these areas, the coverage is expected to gradually move from the lack of conventional water supply system towards nearly full coverage at 95% of all urban and peri-urban areas above mentioned. In parallel, the type of connection is expected to gradually evolve from the service via standpipes towards a large share of the population (75%) with either a house connection or a yard tap.

Subsequent Expansion of Supply

FIPAG has provided updated figures for projected demand to 2027. For the purpose of the analysis, these figures were projected further at the same linear rate of increase, to 2041. These rates of growth appeared to be realistic and acceptable for planning purposes.

To examine options for meeting the demand beyond the first stage of expansion, it is necessary to take into account that the present yield of Corumana Dam, that is, without spillway gates, is fully committed to irrigation users. A large proportion of this yield is taken up by existing sugar plantations, together with committed plans for their expansion. It is therefore assumed that only the additional yield of the raising of the full supply level by means of spillway gates, will be available for urban supply.

The additional yield of the raising of the Corumana full supply level by installing the spillway gates will be sufficient to satisfy urban demand up to 2028. ***Thereafter, to meet further urban demands, construction of Moamba Major Dam will be necessary as subsequent expansion of the supply to Maputo, with the additional yield satisfying the demand up to 2041.***

Investment Staging and Scheduling

In order to postpone unnecessary investment, it is proposed both by this study and some of the preceding reports, that the pipeline bringing water to Maputo be staged. The major cost of the Corumana option is in fact the pipeline and treatment works. Unlike dams, works of this type are easily staged. Rather than build a very large pipeline and treatment works able to deliver the whole available yield, substantial savings are achieved by ensuring that the first stage of the pipeline and treatment works is less than or equal to one half of the yield available. In this case, the size of the first stage has been selected so as to deliver about 44 million m3/year, about one third of the yield of the dam raising. This would be a 50% increase above the full yield available from the Pequenos Libombos Dam, and would ensure safe and adequate supplies up to end 2018.

An analysis undertaken suggests two possible options for scheduling the construction of the Moamba Major Dam:

(i) build the second stage pipeline and treatment works expansion to deliver the whole yield from Corumana, followed by Moamba Major Dam and a pipeline from there to Maputo and treatment works expansion (the Moamba Major investments to start in 2021), or

(ii) build Moamba Major dam plus pipeline and treatment works expansion, followed by the second stage pipeline from Corumana, and treatment works expansion (the Moamba Major investments to start therefore in 2012).

Each new stage must be commenced in time for it to be brought into action as demand begins to exceed the safe level of supply from the preceding stage. Using this principle, the schedules of implementation of the options would be as shown in Figure 2 below. Upon completion of the Moamba Major Dam wall and spillway, a 2 to 3 year period would need to be allowed for it to fill part way before it can be relied upon to provide supplies to Maputo. Such an allowance is not required for the Corumana Dam raising, as this dam is already in operation with a yield greater then current irrigation allocations require.

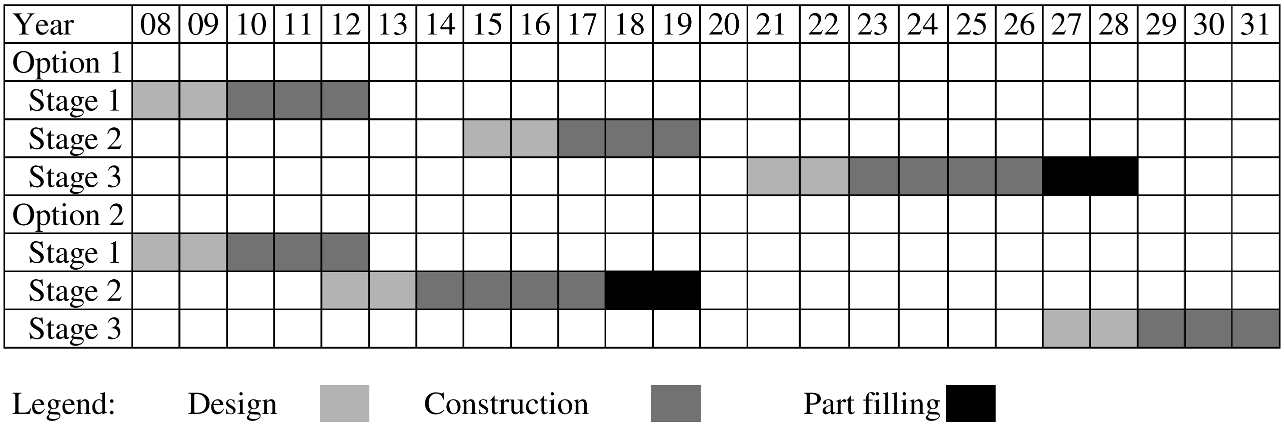

Figure 2. Schedules of Options for Development of the Incomati basin in Mozambique

OPTION 1
- Stage 1: Corumana completion , pipeline, treatment works
- Stage 2: Additional pipeline, treatment works extension
- Stage 3: Moamba Major Dam , pipeline, treatment extension

OPTION 2
- Stage 1: Corumana completion , pipeline, treatment works
- Stage 2: Moamba Major Dam , pipeline, treatment extension
- Stage 3: Additional pipeline

Implications for Irrigation Expansion in the Incomati-Sabie basin

The present yield of Corumana Dam, that is, without spillway gates, is fully committed to irrigation users. A large proportion of this yield is taken up by existing sugar plantations, together with committed plans for their expansion. The current sugarcane area irrigated from Corumana is about 13,000 ha and includes large sugar cane schemes in Xinavane (about 7000 ha) and Maragra /Malangue (about 6000 ha). According to ARA-Sul, the existing water yield from Corumana (without the gates installation) can additionally support about 15,000 ha. Approval has been given for the expansion of sugarcane plantations at Xinavane by 6,000 ha, expected to be completed by 2009. Subsequent options could include the first stage of the COFAMOZA project3 of 10000 ha and/or Malangue (about 5000 ha)4. However, water diversions are not metered at present, so it is not known how much water is withdrawn by present irrigators. A preliminary analysis suggests that the Corumana Dam without spillway gates can support the proposed 28,000 ha of irrigated sugarcane only if rather optimistic water use efficiencies are assumed. Before any decisions are made on further irrigation expansion, withdrawals of water for irrigation should be properly metered and estimates made of present water use and likely efficiencies and water requirements of future developments.

The irrigation expansion plans that are currently under discussion also include the additional 23,500 ha of sugarcane to be developed after 2009 and assume that additional water will be available due to the Corumana gates completion. This includes 20,000 ha of COFAMOZA project Stages 2 and 3 developments,

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[3] Under the COFAMOSA Sugar Cane Project, the Government of Mozambique intends to develop an area of 29,000 ha of irrigated land under sugar cane for sugar and ethanol production. The project area is located in Moamba and Magude Districts of the Province of Maputo Mozambique, and has been selected, mainly, due to the accessible water from Corumana Dam on Sabie River, availability of good irrigable soils and the close proximity to potential local and regional markets for sugar and bio-ethanol.

[4] Information on the plans for irrigation expansion by 2009 and beyond is provided by ARA-Sul.

and 3500 ha in Timanguene. However, the analysis of additional bulk water supply to Maputo indicates that the additional yield of the raising of the full supply level of Corumana, will be needed for urban supply.

Therefore, the important further findings are that

(i) all of the yield made available by both Corumana Dam raising and later by Moamba Major Dam will be eventually needed for urban development, and

(ii) the yield of these projects should not be committed to any other permanent consumptive water use.

As demonstrated by Figure 3, the proposed options of surface water resources development in the Incomati increase system yield in fairly large steps, while demand increases quite smoothly.

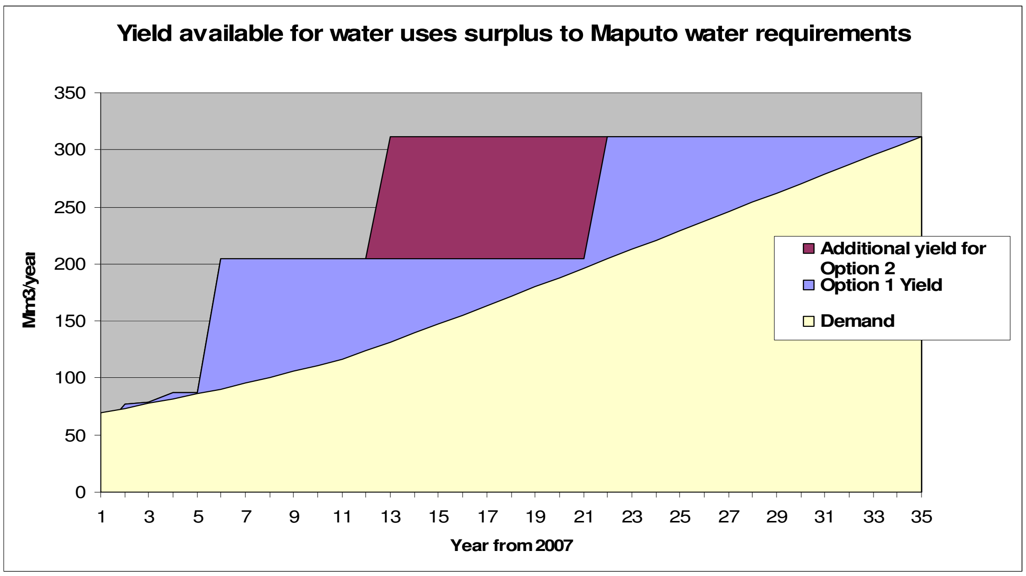


Figure 3. Maputo projected water demand curve and temporary yield surpluses

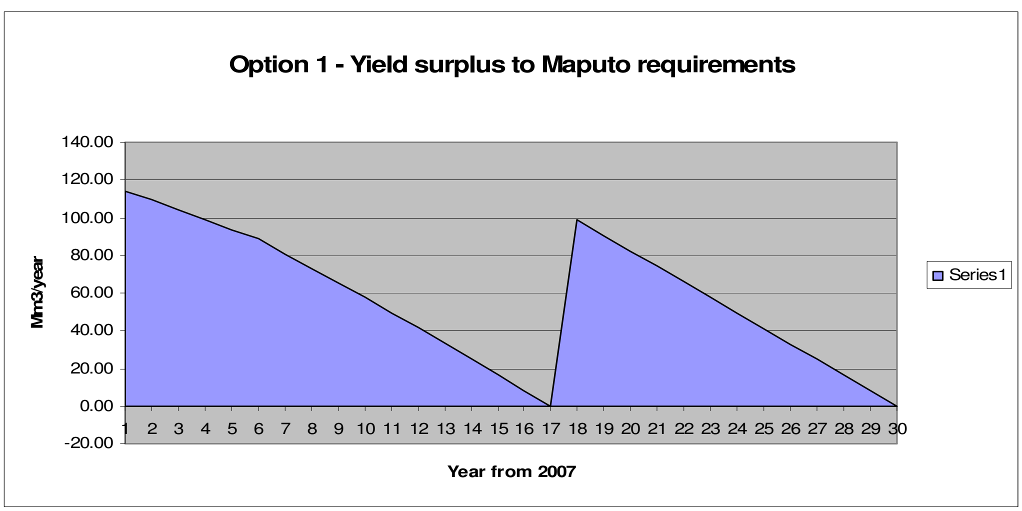


Figure 4. Yield surplus under Option 1

After each step in resource development is taken, there is a temporary surplus of yield, which could possibly be used to achieve other benefits, provided that the water allocation for such uses can easily be withdrawn. The curve of projected demand and the temporary yield surpluses under the two options are shown in Figure 3. The configuration of the yield surplus under Option 1 is shown on Figure 4. Possible benefits of these ***temporary yield surpluses*** include protecting and enhancing downstream environmental values, reducing risks of flood losses, increasing hydropower generation, and supplying temporary small to medium scale irrigation applications (recognising that most irrigation applications are permanent).

Water Yields and Transboundary Flows

The evaluation of the water yields of the project options in this study is based on the yield analysis in [Reference 1, Chapter 11, Table 1-16]. These yields assume

(a) continuation into the future of present levels of development in the basin upstream,
(b) no allowance for instream flow requirements;
(c) the yields shown are historic firm yields, which are defined as the maximum annual water volume that can be abstracted without the dam failing once over the whole hydrological record.

The most common practice is to use slightly less conservative (that is higher) yields than assumption (c) for urban water supply. On the other hand, assumptions (a) and (b) are considered optimistic. In the short term, the effects of these assumptions may largely cancel each other out.

The situation in the medium and long term is, however, less certain. The two main areas of uncertainty are climate change, the effects of which in this region are not known, and the level of irrigation development upstream. The upstream riparian nations, Swaziland and South Africa, particularly the latter, appear to be unable to control abstractions adequately within their borders in line with the tri-state agreements as they stand. If the upstream riparians permit even further abstractions within their borders, this would reduce the yields available to Mozambique in later years. There is therefore a need for the riparians to gain much more control over development and abstractions within their borders, and to work together towards a deeper and more comprehensive agreement, one that will provide them and Mozambique with much greater security of supply than can now be achieved. The authors agree with senior Mozambican officials that this is of the utmost importance to the future development of southern Mozambique.

IV Preliminary Economic Analysis

Economic Cost-Benefit Analysis

A preliminary economic cost-benefit analysis (CBA) was carried out to examine the viability of the proposed options for augmentation of Maputo bulk water supply. The economic CBA is a traditional approach to establishing whether it is justified to invest scarce public resources in the proposed project rather than to use them elsewhere in the economy.

The analysis assumes that the project is developed in the public sector and compares the project's costs and benefits in economic terms, with transfer payments excluded from the valuation of the inputs and outputs. Project costs comprise the lifetime costs of investing and operating the dams and the other components. Costs are expressed in present value terms, discounted at an appropriate rate, over a period of the lifetime of the asset assumed at 50 years. Replacement costs and residual values are taken into account where relevant.

The economic internal rate of return (EIRR), the economic net present value (NPV) and the Benefit/Cost ratio were calculated to evaluate the economic merit of the proposed investments. The latter two discounted at the opportunity costs of capital (OCC). The project is considered economically viable if the EIRR exceeds the OCC, taken in this analysis at 12%.

This cost-benefit analysis is based on a comparison between a baseline scenario and two project scenarios. The costs and benefits of the project scenarios are evaluated in incremental terms relatively to the baseline option assumed in this case as a status quo situation. The two project options considered in this CBA include the same components but have different investment implementation scheduling (as illustrated by Figure 2):

Option 1: Immediate commencement of the Corumana dam raising in 2008 with investments in the second stage pipeline and treatment works expansion commencing in 2015 to provide the capacity to deliver the whole yield from Corumana Dam raising, followed by construction of Moamba Major Dam and a pipeline to Maputo and treatment works expansion (the Moamba Major investments to start in 2021)

Option 2: Immediate commencement of the Corumana dam completion in 2008 with the Moamba Major dam investments, including the pipeline and treatment works expansion, to start in 2012 followed by the second stage pipeline from Corumana and treatment works expansion in 2027.

Investment and Operation & Maintenance Costs

The investment costs are expressed in constant 2006 prices and are net of import duties. The Moamba Major costs are estimated for Full Supply Level (FSL) 112 m. Capital costs of the project include the costs of the dam project, the water treatment works and its extensions, and the pipelines to bring the water to Maputo from the Incomati River at the offtake points for the two dam projects. The costs of the dams, treatment plants and pipelines are taken from [2], [3], and [4]. Some essential requirements such as plant and buildings were incorporated in the Corumana estimate additional to those identified in [3]. Scaling was required of the estimates of the pipelines and treatment plant, and some reconciliation of the somewhat different estimates for these given in [2] and [4]. The estimated investment and operations and management costs are presented in Annex 1. The costs breakdown per year for Options 1 and 2 is presented in Annex 4.

The analysis also takes into account the associated investments within Maputo/Matola required to bring the water made available by the Corumana dam raising and the Moamba Major dam schemes to the consumers5. These expenditures are assumed to be financed outside of the proposed project, however they are necessary to utilize the project water supply benefits and therefore are included in the project total economic costs (Annex 4).

Operations and maintenance costs will initially consist mainly of costs of operation of the dams, pipelines and treatment plant, which were built into their capital costs, based on information in [2] and [3]. The "in-city" O&M costs will mainly comprise pumping costs, and replacement of meters (15 year cycle), some connections, and electrical and mechanical equipment in distribution centers (20 year cycle). These costs will start to become significant after 2027. From 2042, they are estimated as USD 1.2 million per year.

[5] The costs to provide for water delivery within the city boundaries will include water distribution centers, mains, connections and meters. According to FIPAG's estimates, the cost per domestic and commercial connection of this is USD 659 equivalent. This is assumed to increase to USD 800 equivalent over 2012 to 2027 to account for increases in the average lengths of approach mains, and distances to distribution centers, as supplies are extended to cover the whole city. FIPAG also was able to provide projections of total water demand and the numbers of new connections planned over the period to 2028. The authors then projected the demand figures, on a linear basis, to 2041, the date of completion of the last works. Losses were assumed to decrease from 50% to 30% over the period to 2027. On the basis of these connection numbers, total in-city capital costs were calculated and found to be reasonably consistent with experience in other countries.

Expected Benefits

The proposed investments in the completion of the Corumana dam and construction of the Moamba Major dam would result in such main benefits as expanded water supply for Greater Maputo, improved flood control, additional generation of hydropower, and increased fisheries. For the purpose of this preliminary analysis, benefit estimates in the feasibility studies on Moamba Major Dam (Norconsult 2003) and the raising of full supply level of Corumana Dam (Lahmeyer International 2002) were used as a starting point in calculating the value of the identified economic benefits. The estimated benefits are as follows:

Flood control: Flood control benefits of Moamba Major dam estimated at 2.51 USD million. Flood control benefits from the Corumana gates are estimated at 25% of Moamba Major flood control benefits. The total flood control benefits are a sum of those from the Corumana upgrade and Moamba Major dam.

Energy: Mean annual production of energy from Moamba Major would be 38.2 Gwh. The economic price is estimated at USD 0.025 per kwh. The mean annual energy production from Moamba Major is estimated at USD 0.942 million per year (Data source: Moamba Major feasibility study report: Norconsult 2003). Corumana energy production benefit is estimated at USD 0.188 million per year (Raising of Full Supply Level of Corumana Dam feasibility study). Energy production per m3 for Corumana is firm incremental energy production per annum divided by incremental firm yield, or 0.22 Kwh/m3 (Corumana Feasibility Study). Energy production per m3 for Moamba Major Dam was is 0.16 Kwh per m3 (based on estimates of firm yield of 107 Mm3 / year, and firm energy production is 17 GwH / year: Moamba Major Dam feasibility study).

Fisheries: It is estimated that the economic price per 1 kg of fish is $0.95. Normal annual catch from existing Corumana reservoir is 356 ton (estimates by Ara Sul). The surface area of the existing Corumana reservoir is 71 km2 at the present full supply level. The surface area of the proposed Moamba Major reservoir will be 54.48 km2. The potential catch from Moamba Major is estimated at 273.17 tons per year. Corumana completion will increase the surface area of the reservoir to 91 km2, which will lead to incremental benefits in fisheries of USD 0.0953 million. For Moamba Major the benefit is estimated at USD 0.26 million.

Maputo water supply: Municipal water supply benefits are estimated based on the consumers' willingness to pay (WTP) of USD0.76/m3 of water supplied. It is estimated that domestic WS constitutes 77% of total Maputo water demand (Based on the analysis of data provided by FIPAG). Water supply benefits for industries constitute about 14% of the total demand and commercial consumption about 9%. WTP for industries and services is conservatively assumed to be the same as for domestic consumers.

The estimated economic benefits of Options 1 and 2 are presented in Annex 3. The water supply benefits constitute more than 90% of the total value of the project benefits (see Table 1).

As discussed in Section 3 above, the proposed investments will also result in some temporary yield surpluses, and possible benefits of using this water include protecting and enhancing downstream environmental values, reducing risks of flood losses, increasing hydropower generation, and supplying temporary small to medium scale irrigation applications. While these benefits are acknowledged, they have not been quantified in this preliminary analysis and are assumed to be relatively insignificant compared with the value of the main benefits.

Table 1: Composition of the project total economic benefits (%)

	Flood Control	Energy Production	Fisheries	Maputo Water Supply	Total
Option 1	4.0	1.3	0.5	94.2	100
Option 2	6.8	2.4	0.8	90.0	100

Results of Preliminary Economic Analysis

A preliminary economic analysis was carried out for the identified project options. Details of the analysis are presented in Annex 4. The results of the analysis are summarized in Table 2 below.

Table 2. Results of Preliminary Economic Analysis

	EIRR (%)	NPV (at 12%) $Million	Benefit/ Cost Ratio
Option 1	15.9	63.7	1.38
Option 2	12.4	10.7	1.05

The analysis shows that both project options are economically feasible, with Option 2 showing lower results. For Option 1 the EIRR is estimated at 15.9%, the NPV is calculated at $ 64 million and Benefit/Cost (B/C) ratio - at 1.4, at 12% discount rate. Option 2 has the estimated EIRR of 12.4%, the NPV - $11 million and B/C ratio of 1.05.

Both options are therefore viable options in economic terms, with Option 1 to be economically preferable with the significantly higher EIRR and B/C ratio. Results of a sensitivity analysis demonstrate however that Option 2 is sufficiently sensitive to variations in such key assumption as project total costs. The results of the sensitivity analysis with alternative scenarios on the variations in the project costs and benefits and the associated values of the key project economic indicators are shown in Table 3.

Table 3. Results of Sensitivity Analysis

Indicator	Units	Value	
		Option 1	Option 2
Project Cost Overrun of 5%			
NPV	$ million	55.3	-0.6
ERR	%	15.2	12
B/C	-	1.3	1
Project Cost Overrun 10%			
NPV	$ million	47	-11.9
ERR	%	14.6	11.6
B/C	-	1.25	0.95
Project Cost Overrun 20%, benefits Increased 10%			
NPV	$ million	47	-10.9
ERR	%	14.7	11.6
B/C	-	1.26	0.96
Project Cost Overrun 35%			
NPV	$ million	5	-68
ERR	%	12.2	9.8
B/C	-	1.02	0.8

The results of the sensitivity analysis demonstrate that Option 2 becomes economically unfeasible with the increase in project costs of only 5%. The World Bank's experience6 demonstrates that average cost overruns for construction of multipurpose dams often come to 30% - 40%. Assuming the cost overruns of 20%, Option 2 will remain unviable even with the increase in project benefits by 10%.

Option 1 at the same time is able to withstand a cost increase up to 35% demonstrating its economic robustness (Table 3). For Option 1 to become economically unfeasible, the project costs would need to be increased by 40% (in this case the EIRR would fall just below 12% and NPV would be negative). However, the increase in the value of project benefits by only 5% would bring Option 1 back to the economic viability even with the cost overrun of 40%.

The project economic justification would benefit from further identification and evaluation of the benefits associated with the use of surplus water yields. This may include benefits from additional hydropower generation, further reducing risks of flood losses, and small to medium scale irrigation applications relying upon the temporary availability of water.

It is also recommended to undertake financial analysis to investigate the conditions that are needed to ensure the financial viability and sustainability of the project from the perspective of ARA Sul as an operator of the assets. This objective would be achieved through assessing user charges at which the agency can achieve full or partial cost-recovery of the capital and O&M costs associated with the construction and operation of the proposed infrastructure.

V Conclusions

1. Growing water needs for the Greater Maputo area require urgent investments in completion of the Corumana dam in order to meet the shortage in water supply for Maputo in 2011/12. Construction of the Moamba Major dam will be also necessary to meet the projected future demand for the urban and industrial development of the Greater Maputo area after 2028.

2. Two possible options for scheduling the construction works for Moamba Major Dam have been identified:

   Option 1 assumes the immediate commencement of the Corumana dam completion with investments in the second stage pipeline and treatment works expansion commencing in 2015 to provide the capacity to deliver the whole yield from Corumana Dam raising, followed by construction of Moamba Major Dam and a pipeline to Maputo and treatment works expansion (the Moamba Major investments to start in 2021);

   Option 2 also assumes the immediate commencement of the Corumana dam completion with the Moamba Major dam investments to start in 2012 with the pipeline and treatment works expansion, followed by the second stage pipeline from Corumana and treatment works expansion in 2027.

3. A preliminary economic analysis was carried out to assess economic viability of the proposed two investment options for additional Maputo bulk water supply. The results of the analysis demonstrate that both options appear to be economically viable, with Option 1 having a strong economic preference over Option 2. The economic feasibility of Option 2 appeared to be marginal, with a strong sensitivity of its economic efficiency indicators to slight increases in the project costs. Therefore, the in-

[6] The World bank experience with Large Dams: A preliminary Review of Impacts – Vol.1 Washington DC: World Bank Operations Evaluation Department. 1996

vestment alternative that postpones investments in the Moamba Major dam until 2021 (Option 1) is recommended to the Government for implementation as economically preferable.

4. Ultimately the full yields of both the Corumana Dam heightening and the Moamba Major Reservoir will be required to meet the needs of the greater Maputo urban and industrial area. Surplus water yields will be temporarily available for other uses during some years directly after completion the Corumana dam and after completion the Moamba Major dam. This temporary surplus of yield could possibly be used by other water uses provided that the water allocation for such uses can easily be withdrawn when the water is needed for the urban supply.

5. Given that the existing water yield from Corumana is not used efficiently, and that there is an established future demand from Maputo, any permanent allocation for irrigation of the additional water made available by upgrading the Corrumana dam should not be permitted. Even if this water is used for production of such high value crops as sugar cane and would bring employment and other additional benefits, it will not justify the investments that will be required to find alternative supplies from more expensive sources for Maputo water supply in the future. This water needs to be reserved for future urban and industrial use.

6. Any determination of the economics of a scheme such as bio-fuel production or other irrigated crop production in the South should build-in a time limitation on the availability of water. Otherwise the loss of investments when water is redirected for higher value use would not be factored into feasibility considerations and would cause difficult competing water interests.

7. The increasing physical water scarcity in the South of Mozambique stresses the need for the government to take a longer term, multi sector strategic view on water use planning. A consideration needs to be given to policy decisions, which would allocate water in the South towards the higher value users, diversify economic activities in the region away from water dependent agriculture, and promote commercial scale agriculture (such as sugarcane production) into the other regions of the country with higher levels of water availability and lower water costs (for example, in the Pungue and Zambezi river basins). Since the immediate construction of Moamba Major dam appears neither necessary nor economically sound, investments in water resources infrastructure in the Pungue basin (the Bua Maria dam or its alternatives) could be considered as a higher priority for the public investment planning providing for long- term agricultural development in this region.

References

1. Government of Mozambique, First National Water Development Project, "National Water Resources Development Plan for the Inkomati Basin" (NDF 197-5) January 2003.
2. Government of Mozambique, National Directorate of Water, National Water Development Project - 1 "Feasibility Study Moamba Major Dam" Norconsult, November 2003.
3. Government of Mozambique, National Directorate of Water, First National Water Development Project, "Raising the Full Supply Level of Corumana Dam – Feasibility Study Report", Lahmeyer International et al, January 2002.
4. Government of Mozambique, Administração Regional de Águas do Sul (ARA-Sul) "Estudo para o Abastecimento de Água à Fábrica de Ferro e Aço – Maputo", Technica Engenheros Consultores LDA, Março 2001.

ANNEX 1 - Cost Estimates of Maputo Bulk Water Supply Options

Basic data: Main source "WR Development Plan for Inkomati River Basin Nov 2003"
Raises FSL of Corumana from 111 masl to 117 masl
Increases capacity from 875 Mm3 to 1363 Mm3
Increases firm yield from 383 Mm3/year to 500 Mm3/year

Raising Curumana + 1st stage pipeline/treatment)	2006 cost $million
Curumana dam completion	
Corumana Construction works	23.21
Office and housing	2.58
Office equipment	0.17
Resettlement	0.62
Vehicles and plant	0.45
Total Works at Corumana Dam	27.02
Pipeline/treatment	
Intake and pumping station at Sabie	0.84
Pipeline Sabie to Moamba	7.85
Treatment plant	11.21
Booster station, Moamba	0.45
Pipeline Moamba to Maputo	18.22
Storage before and after treatment	3.92
Pipes connecting service centers	1.68
Power supply, 33kv line plus appurtenances	0.56
Total, all except works at Corumana Dam	44.73
Engineering supervision @10%	4.47
Total Works stage 1	76.22
Design @4% for Coru.,@8% PL & TW	4.55
TOTAL	**80.77**

2nd stage Corumana pipeline / treatment	
Extend intake and PS	0.6
2nd pipeline Sabie-Moamba	12.1
Extend treatment plant	17.2
Extend booster station	0.7
2nd pipeline Moamba-Maputo	28.0
Storage before and after treatment	6.0
Total excluding design and supervision	64.6
Eng supervision supervision @10%	6.5
Total Works	71.1
Design @8%	5.2
TOTAL	**76.3**
TOTAL Corumana + stages 1 & 2 pipeline & treatment	**157.0**

Moamba Major Dam and Pipeline

Dam, including resettlement	203.7
Pipeline & Treatment Works	52.6
Power Station	22.4
Design & EIA	22.3
TOTAL	**301.0**

Notes:
Pipeline and Treatment Works:
Stage 1 capacity as for Moamba Major i.e. 130000m3/day or 47.5 Mm3/year. 1.000 meter diameter pipe, 1.5m3/sec

Stage 2 capacity: the Moamba Major FS gave options of stages 2 and 3, each smaller than stage 1. However this means upgrading at ever shortening intervals. Stage 2 pipeline is therefore proposed bigger than the one for stage 1, at 1.2m diameter, allowing capacity to use all of the 117 Mm3/y yield made available by the Corumana gates.

ANNEX 2 - Annual Operations & Maintenance Costs

Corumana Works at Dam

0.20% of Civil Works Costs (These allowances are from Corumana Feasibility Study, p24)
1.20% of Equipment Costs

	$'000/year	As at 2002 $/year	As at 2006 $/year	
Civil Works costs	12960			
CW Contingencies	1850			
Total	14810			
Civil Works O&M		29620	33206	
Mech & Elec costs	3370			
M&E Contingencies	338			
Total	3708			
M & E O&M		44496	49883	
Total O&M, av per annum		74116	**83100**	Year 2013 to 2061

Pipelines and Treatment Works (From Moamba Major Feasibility Study Table 8.3.1)

		$/year	
Option 1 & 2, Stage 1	400000	**448430**	Year 2013 to 2061
Option 1 Stage 2. (Option 2 Stage 3 is the same)	500000	**560538**	Option 1: Year 2011 to 2061
	900000	1001000	

Moamba Major Dam, excluding pipelines				
			The Moamba Major feasibility study contains inadequate information. We therefore use here the same O&M allowances as for Corumana Dam Raising as above	
	$,000/year			
Civil Works costs	86830			
CW Contingencies	43415		2006 values	
Total	130245		$/year	
Civil Works O&M		260490	292029	
Mech & Elec costs	18185			
M&E Contingencies	9092			
Total	27277			
M & E O&M		327324	366955	
Pipeline for Moamba Major			560538	
Total O&M, av per annum		587814	**1220000**	658984

ANNEX 3 - Project Benefits by Option

Calendar Year	Project Year	Incremental bulk water supply for Maputo (Mm3/y)	Yield Surplus to Maputo WS Option 1 (Mm3/y)	Yield Surplus to Maputo WS Option 2 (Mm3/y)	Flood Control Option 1 $ Million	Flood Control Option 2 $ Million	Energy Production Option 1 $ Million	Energy Production Option 2 $ Million	Fisheries Option 1 $ Million	Fisheries Option 2 $ Million	Maputo Water Supply Option 1 $ Million	Maputo Water Supply Option 2 $ Million	Project Benefits Option 1 $ Million	Project Benefits Option 2 $ Million
2007	0													
2008	1	0.00									0.00	0.00	0.00	0.00
2009	2	0.00									0.00	0.00	0.00	0.00
2010	3	0.00									0.00	0.00	0.00	0.00
2011	4	0.00									0.00	0.00	0.00	0.00
2012	5	2.59	114.41	114.41							1.97	1.97	1.97	1.97
2013	6	7.75	109.25	109.25	0.63	0.63	0.188	0.188	0.0953	0.0953	5.89	5.89	6.80	6.80
2014	7	12.91	104.09	104.09	0.63	0.63	0.188	0.188	0.0953	0.0953	9.81	9.81	10.72	10.72
2015	8	18.07	98.93	98.93	0.63	0.63	0.188	0.188	0.0953	0.0953	13.73	13.73	14.64	14.64
2016	9	23.22	93.78	93.78	0.63	0.63	0.188	0.188	0.0953	0.0953	17.65	17.65	18.56	18.56
2017	10	28.38	88.62	88.62	0.63	0.63	0.188	0.188	0.0953	0.0953	21.57	21.57	22.48	22.48
2018	11	36.19	80.81	80.81	0.63	3.14	0.188	1.13	0.0953	0.3548	27.50	27.50	28.41	32.13
2019	12	43.99	73.01	253.02	0.63	3.14	0.188	1.13	0.0953	0.3548	33.43	33.43	34.34	38.06
2020	13	51.79	65.21	237.41	0.63	3.14	0.188	1.13	0.0953	0.3548	39.36	39.36	40.27	43.99
2021	14	59.60	57.40	221.81	0.63	3.14	0.188	1.13	0.0953	0.3548	45.29	45.29	46.20	49.92
2022	15	67.40	49.60	206.20	0.63	3.14	0.188	1.13	0.0953	0.3548	51.22	51.22	52.13	55.85
2023	16	75.64	41.36	189.71	0.63	3.14	0.188	1.13	0.0953	0.3548	57.49	57.49	58.40	62.11
2024	17	83.89	33.11	173.22	0.63	3.14	0.188	1.13	0.0953	0.3548	63.76	63.76	64.67	68.38
2025	18	92.14	24.86	156.73	0.63	3.14	0.188	1.13	0.0953	0.3548	70.02	70.02	70.93	74.65
2026	19	100.38	16.62	140.24	0.63	3.14	0.188	1.13	0.0953	0.3548	76.29	76.29	77.20	80.91
2027	20	108.63	8.37	123.75	3.14	3.14	1.13	1.13	0.3548	0.3548	82.56	82.56	87.18	87.18
2028	21	116.87	0.13	107.25	3.14	3.14	1.13	1.13	0.3548	0.3548	88.82	88.82	93.45	93.45
2029	22	125.32	98.88	98.88	3.14	3.14	1.13	1.13	0.3548	0.3548	95.24	95.24	99.87	99.87
2030	23	133.56	90.64	90.64	3.14	3.14	1.13	1.13	0.3548	0.3548	101.51	101.51	106.13	106.13
2031	24	141.81	82.39	82.39	3.14	3.14	1.13	1.13	0.3548	0.3548	107.78	107.78	112.40	112.40
2032	25	150.06	74.14	74.14	3.14	3.14	1.13	1.13	0.3548	0.3548	114.04	114.04	118.67	118.67
2033	26	158.30	65.90	65.90	3.14	3.14	1.13	1.13	0.3548	0.3548	120.31	120.31	124.93	124.93
2034	27	166.55	57.65	57.65	3.14	3.14	1.13	1.13	0.3548	0.3548	126.58	126.58	131.20	131.20
2035	28	174.79	49.41	49.41	3.14	3.14	1.13	1.13	0.3548	0.3548	132.84	132.84	137.47	137.47
2036	29	183.04	41.16	41.16	3.14	3.14	1.13	1.13	0.3548	0.3548	139.11	139.11	143.73	143.73
2037	30	191.28	32.92	32.92	3.14	3.14	1.13	1.13	0.3548	0.3548	145.38	145.38	150.00	150.00
2038	31	199.53	24.67	24.67	3.14	3.14	1.13	1.13	0.3548	0.3548	151.64	151.64	156.27	156.27
2039	32	207.77	16.43	16.43	3.14	3.14	1.13	1.13	0.3548	0.3548	157.91	157.91	162.53	162.53
2040	33	216.02	8.18	8.18	3.14	3.14	1.13	1.13	0.3548	0.3548	164.18	164.18	168.80	168.80
2041	34	224.27	0.00	0.00	3.14	3.14	1.13	1.13	0.3548	0.3548	170.44	170.44	175.07	175.07
2042	35	224.27	0.00	0.00	3.14	3.14	1.13	1.13	0.3548	0.3548	170.44	170.44	175.07	175.07
2043	36	224.27	0.00	0.00	3.14	3.14	1.13	1.13	0.3548	0.3548	170.44	170.44	175.07	175.07
2044	37	224.27	0.00	0.00	3.14	3.14	1.13	1.13	0.3548	0.3548	170.44	170.44	175.07	175.07
2045	38	224.27	0.00	0.00	3.14	3.14	1.13	1.13	0.3548	0.3548	170.44	170.44	175.07	175.07
2046	39	224.27	0.00	0.00	3.14	3.14	1.13	1.13	0.3548	0.3548	170.44	170.44	175.07	175.07
2047	40	224.27	0.00	0.00	3.14	3.14	1.13	1.13	0.3548	0.3548	170.44	170.44	175.07	175.07
2048	41	224.27	0.00	0.00	3.14	3.14	1.13	1.13	0.3548	0.3548	170.44	170.44	175.07	175.07
2049	42	224.27	0.00	0.00	3.14	3.14	1.13	1.13	0.3548	0.3548	170.44	170.44	175.07	175.07
2050	43	224.27	0.00	0.00	3.14	3.14	1.13	1.13	0.3548	0.3548	170.44	170.44	175.07	175.07
2051	44	224.27	0.00	0.00	3.14	3.14	1.13	1.13	0.3548	0.3548	170.44	170.44	175.07	175.07
2052	45	224.27	0.00	0.00	3.14	3.14	1.13	1.13	0.3548	0.3548	170.44	170.44	175.07	175.07
2053	46	224.27	0.00	0.00	3.14	3.14	1.13	1.13	0.3548	0.3548	170.44	170.44	175.07	175.07
2054	47	224.27	0.00	0.00	3.14	3.14	1.13	1.13	0.3548	0.3548	170.44	170.44	175.07	175.07
2055	48	224.27	0.00	0.00	3.14	3.14	1.13	1.13	0.3548	0.3548	170.44	170.44	175.07	175.07
2056	49	224.27	0.00	0.00	3.14	3.14	1.13	1.13	0.3548	0.3548	170.44	170.44	175.07	175.07
2057	50	224.27	0.00	0.00	3.14	3.14	1.13	1.13	0.3548	0.3548	170.44	170.44	175.07	175.07

ANNEX 4 - Cost Benefit Analysis

		COSTS (USD million)								Total Project Benefits		Net Project Benefits		Total costs	
		OPTION 1: Moamba Major Construction Starts in 2022				OPTION 2: Moamba Major Construction Starts in 2013									
Calenda	Projec	Corumana Dam		Moamba Major Dam		Corumana Dam		Moamba Major Dam		Option 1	Option 2	Option 1	Option 2	option 1	option 2
Year	Year	Investment	O&M	Investment	O&M	Investment	O&M	Investment	O&M						
2007	0														
2008	1	4				4				0	0	-4.0	-4	4	4
2009	2	0.55				0.55				0	0	-0.6	-0.6	0.6	0.6
2010	3	19				19				0	0	-19.0	-19.0	19.0	19.0
2011	4	34				34				0	0	-34.0	-34.0	34.0	34.0
2012	5	23.22				23.22		11		1.97	1.97	-28.5	-39.5	30.5	41.5
2013	6		0.532				0.532	11.29		6.80	6.80	-1.0	-12.3	7.8	19.1
2014	7		0.532				0.532	26		10.72	10.72	2.9	-23.1	7.8	33.8
2015	8	4.17	0.532				0.532	86		14.64	14.64	2.6	-79.2	12.0	93.8
2016	9	1	0.532				0.532	124		18.56	18.56	9.7	-113.3	8.8	131.8
2017	10	15	0.532				0.532	42.68		22.48	22.48	-0.4	-28.0	22.8	50.5
2018	11	35	0.532				0.532		1.220	28.41	32.13	-18.3	19.2	46.7	13.0
2019	12	21.1	0.532				0.532		1.220	34.34	38.06	1.5	25.1	32.8	13.0
2020	13		1.092				0.532		1.220	40.27	43.99	28.0	31.0	12.3	13.0
2021	14		1.092	11			0.532		1.220	46.20	49.92	22.9	37.0	23.3	13.0
2022	15		1.092	11.29			0.532		1.220	52.13	55.85	28.6	42.9	23.6	13.0
2023	16		1.092	26			0.532		1.220	58.40	62.11	20.1	49.2	38.3	13.0
2024	17		1.092	86			0.532		1.220	64.67	68.38	-33.6	55.4	98.3	13.0
2025	18		1.092	124			0.532		1.220	70.93	74.65	-65.4	61.7	136.3	13.0
2026	19		1.092	42.68			0.532		1.220	77.20	80.91	22.2	68.0	55.0	13.0
2027	20		1.092		1.220	4.17	0.532		1.220	87.18	87.18	73.7	70.1	13.5	17.1
2028	21		1.092		1.220	1	0.532		1.220	93.45	93.45	82.3	81.9	11.1	11.6
2029	22		1.092		1.220	15	0.532		1.220	99.87	99.87	88.8	74.3	11.1	25.6
2030	23		1.092		1.220	35	0.532		1.220	106.13	106.13	95.0	60.6	11.1	45.6
2031	24		1.092		1.220	21.1	0.532		1.220	112.40	112.40	101.3	80.7	11.1	31.7
2032	25		1.092		1.220		1.092		1.220	118.67	118.67	107.6	107.6	11.1	11.1
2033	26		1.092		1.220		1.092		1.220	124.93	124.93	113.8	113.8	11.1	11.1
2034	27		1.092		1.220		1.092		1.220	131.20	131.20	120.1	120.1	11.1	11.1
2035	28		1.092		1.220		1.092		1.220	137.47	137.47	126.4	126.4	11.1	11.1
2036	29		1.092		1.220		1.092		1.220	143.73	143.73	132.6	132.6	11.1	11.1
2037	30		1.092		1.220		1.092		1.220	150.00	150.00	138.9	138.9	11.1	11.1
2038	31		1.092		1.220		1.092		1.220	156.27	156.27	145.2	145.2	11.1	11.1
2039	32		1.092		1.220		1.092		1.220	162.53	162.53	151.4	151.4	11.1	11.1
2040	33		1.092		1.220		1.092		1.220	168.80	168.80	157.7	157.7	11.1	11.1
2041	34		1.092		1.220		1.092		1.220	175.07	175.07	164.0	164.0	11.1	11.1
2042	35		1.092		1.220		1.092		1.220	175.07	175.07	164.0	164.0	11.1	11.1
2043	36		1.092		1.220		1.092		1.220	175.07	175.07	171.6	171.6	3.5	3.5
2044	37		1.092		1.220		1.092		1.220	175.07	175.07	171.6	171.6	3.5	3.5
2045	38		1.092		1.220		1.092		1.220	175.07	175.07	171.6	171.6	3.5	3.5
2046	39		1.092		1.220		1.092		1.220	175.07	175.07	171.6	171.6	3.5	3.5
2047	40		1.092		1.220		1.092		1.220	175.07	175.07	171.6	171.6	3.5	3.5
2048	41		1.092		1.220		1.092		1.220	175.07	175.07	171.6	171.6	3.5	3.5
2049	42		1.092		1.220		1.092		1.220	175.07	175.07	171.6	171.6	3.5	3.5
2050	43		1.092		1.220		1.092		1.220	175.07	175.07	171.6	171.6	3.5	3.5
2051	44		1.092		1.220		1.092		1.220	175.07	175.07	171.6	171.6	3.5	3.5
2052	45		1.092		1.220		1.092		1.220	175.07	175.07	171.6	171.6	3.5	3.5
2053	46		1.092		1.220		1.092		1.220	175.07	175.07	171.6	171.6	3.5	3.5
2054	47		1.092		1.220		1.092		1.220	175.07	175.07	171.6	171.6	3.5	3.5
2055	48		1.092		1.220		1.092		1.220	175.07	175.07	171.6	171.6	3.5	3.5
2056	49		1.092		1.220		1.092		1.220	175.07	175.07	171.6	171.6	3.5	3.5
2057	50		1.092		1.220		1.092		1.220	175.07	175.07	171.6	171.6	3.5	3.5
						NPV	63.7	10.7		231.2	237.6			167	227
						EIRR	15.9%	12.42%							
						B/C ratio	1.38	1.047							

Mozambique Country Water Resources Assistance Strategy:
Making Water Work for Sustainable Growth and Poverty Reduction

Annex III

WB Memorandum: "Role of Water in the Mozambique Economy"

June, 2005

(Note: This document was prepared as a first phase of the preparation of the Mozambique Country Water Resources Assistance Strategy. Some of the information in this document will have been superseded by more recent research and analysis. Furthermore, some information in this Memorandum is duplicated in the full Country Water Resources Assistance Strategy.)

The Role of Water in the Mozambique Economy
– *Identifying Vulnerability and Constraints to Growth –*

MEMORANDUM
June, 2005

WORLD BANK

The Role of Water in the Mozambique Economy
– *Identifying Vulnerability and Constraints to Growth* –

MEMORANDUM
June, 2005

Contents

Abbreviations

AIDS	Acquired Immune-Deficiency Syndrome
ARA	Regional Water Administration
DNA	National Directorate of Water
EdM	Electricidade de Mocambique – State power utility
EIA	Environmental Impact Assessment
FEWS	Famine Early Warning System
GDP	Gross Domestic Product
ha	hectare
HDI	Human Development Index
HCB	Hidroelectrica de Cahora Bassa - the dam operating company
HICEP	Hidraulica de Chokwé, a Public Company
HIV	Human Immuno-deficiency Virus
IAF	Inquerito ass Agregades Famlilares (Household Surveys)
INAM	The National Meteorology Institute
INGC	National Institute for Disaster Management
IWRM	Integrated Water Resources Management
km	kilometre
kWh	Kilowatt hour
m	metre
MDG	Millennium Development Goals
MDSAR	Massingir Dam and Smallholder Rehabilitation Project
mm	millimetre
NGO	Non-governmental Organisation
PARPA	Action Plan for the Reduction of Absolute Poverty
PROAGRI	National Agricultural Programme
PRSP	Poverty Reduction Strategy Paper
WFP	World Food Programme
WRM	Water Resources Management

The Role of Water in the Mozambique Economy
– Identifying Vulnerability and Constraints to Growth –

MEMORANDUM[1]

1 Executive Summary

This study is the first stage of a two stage process. It is limited in scope and has been undertaken to gain a clearer perspective of the conditions which face Mozambique with regards to the development of its water resources and the impact of water resources on the country's economy. The second stage will be to prepare a Country Water Resources Assistance Strategy which will build on this report. It was thus the purpose of this study to identify issues which need to be addressed, rather than to make specific recommendations.

Mozambique's economy is both highly vulnerable and increasingly constrained due to a number of water related factors. These factors include the natural, highly variable climatic realities of the region, the high level of dependence upon international water resources and the historic underdevelopment of water infrastructure (including limited water storage). Mozambique's poverty is closely linked to its dependence on rain-fed subsistence farming in the context of highly variable rainfall and frequent droughts. Growing water demands from the major sectors of the economy, especially agriculture, will not be able to be met by the existing water storage infrastructure which imposes a serious constraint on medium-term and long-term growth prospects.

The following list summarizes the main factors which this study raises. Each item is explained in greater detail in the report which follows.

1. Mozambique has abundant water resources in overall, absolute terms;
2. The geographic distribution of water resources across the country is uneven with the south being substantially drier than the north;
3. At a sub-catchment, local level there exists a high degree of water related uncertainty due to the inaccessibility of water in the main streams of larger rivers (the 'scale' factor);
4. Watersheds are degrading due to increasing population pressure and poor land-use practices,
5. There is a high dependence on waters in international river basins (over half of the national water resources are shared with neighboring countries);
6. The current stock of water infrastructure is degraded and underdeveloped – the current storage in the country is 5% of the annual runoff (excluding the Cahora Bassa Dam which is a single purpose hydropower dam built in a very remote part of the country from which only 10% of the power generated is consumed in Mozambique) – minimum suggested is 40% to provide 50% of annual runoff at 80-90% assurance. Excluding Cahora Bassa, the storage per person is estimated at 330 m^3 (South Africa = 746 m^3; North America = 6,150 m^3)
7. The future needs of water-dependent economic sectors in some river basins cannot be met with the current infrastructure which places a constraint on future economic growth;
8. The climate is highly variable with frequent droughts and floods;

[1] Prepared by Len Abrams, Senior Water Resources Specialist, Africa Region, AFTU1, based on two background papers prepared as part of the study:-
"*The Role of Water in the Mozambique Economy – Identifying Vulnerability and Constraints to Growth",* Rimma Dankova, February 12, 2005;
"Local Vulnerability Study" S. Gaye Thompson, September 2004

9. The cost of each major water shock (drought or flood) can be very high [2000 floods: US$ 550 million, 1994 drought loss in agricultural production alone: US$ 86 million], total cost of water shocks in the period 1980-2003 was about US$1.75 billion. Assuming a 5% annual GDP growth, the total economic costs due to floods and droughts will be approximately US$3 billion between now and 2030 if no mitigation steps are taken (this does not include the cost of constrained growth).
10. The costs of water shocks to the poor are largely hidden and unaccounted for. The rural poor, who are largely dependent upon rain-fed subsistence agriculture, are particularly vulnerable to water shocks.
11. Based on events from 1981 – 2004, Mozambique GDP growth is cut by 5.6% on average when a major water shock occurs. Historically a major disaster occurs once every five years, resulting is an average annual reduction in GDP growth in Mozambique of 1.1% due to the impacts of water shocks. This figure does not include the loss of potential growth as a result of constraints due to inadequate water infrastructure development, even if there were no floods or droughts.
12. In 1999, 2000 and 2001 annual expenditures on water resources was US$ 0.32 million, US$ 0.29 million and US$ 0.35 million respectively – this is on average 0.006% of GDP.
13. There is a limit to the extent to which Mozambique's problems can be addressed through improving the management of water resources alone without investing in infrastructure. At this stage of Mozambique's development, significant returns on investments may be achieved from infrastructure development. Proper management of water remains important, however, investments without proper management will be ineffective.
14. Investments need to include both large and small scale interventions to support industrial, urban and commercial irrigation development, as well as addressing small-holder agricultural needs.

It must be noted that these matters are not "water problems" – they are grave issues facing the economy of Mozambique as a whole. They impact on the whole of the country and on the poor in particular. They are of a magnitude and of an all-encompassing nature that will impinge on and negatively affect the best efforts made in all other sectors. Investment in water resources infrastructure is the only way in which Mozambique can stop the continuous drain on the economy and the extensive human costs cost caused by recurrent floods and droughts, and the only way to provide reliable sources of water which any economy needs to grow in strength and diversity.

2 Introduction

The dynamics of growth and poverty reduction in any country are a complex interaction of a very large number of different factors and Mozambique is no exception. This brief Memorandum is the product of a study undertaken by the World Bank to investigate the role of water in the economy of Mozambique as part of the Bank's ongoing support to the water sector in the country.

The study was undertaken in the context of the Government of Mozambique's ongoing process of strengthening the country's water resources management, development and protection. The study contributes to the development of the second National Action Plan for the Reduction of Absolute Poverty (PARPA2), the World Bank's ongoing macro-economic analysis including the preparation of a Country Economic Memorandum and, in particular, the study draws on the work done under the IDA financed National Water Development Project I (NWDPI).

The specific contribution of this study, beyond the work noted above, is to review the role of water resources in the economy as a whole and the long term economic impacts of under investment in water infrastructure. This adds to the work done in various studies on the financial costs of historical drought and flood events.

The study comprised the preparation of two background papers, one addressing local vulnerability of rural communities to water and the other reviewing the economy wide impacts of water shocks (droughts and floods) and the constraints to growth as a consequence of under investment in water infrastructure. The process also included a Seminar held in Maputo on February 24, 2005 to discuss the background papers.

> **This study is Phase I of a process which will include, as Phase II, the preparation of a Country Water Resources Assistance Strategy for Mozambique which will refine the analysis prepared in this report.**

2.1 Objectives

The objective of the study is:-

1. To better understand the impacts of water resources on the economy of Mozambique;
2. To provide initial guidance to the Government of Mozambique on addressing the issues raised by the analysis, to be followed in greater detail by the preparation of a Country Water Resources Assistance Strategy.

These objectives will be achieved by undertaking :

1. A review of the impacts of both water shocks (droughts and floods) <u>and</u> constraints on growth and poverty reduction caused by under-investment in water resources infrastructure;
2. An assessment of the impacts at the macro / economy wide level. Impacts at the micro level, particularly related to impact on the rural poor, were also studied.

2.2 Scope of study

The issues which the study addresses are as follows:-

a) the natural characteristics of Mozambique's water resources, including uneven geographic distribution of water resources, localized seasonal water shortages, highly variable climate, and high dependency on shared international river basins;
b) the linkages between the main economic sectors to water resources and water-related constraints for the development of these sectors;
c) the assessment of impacts of climate variability on the country's macroeconomic performance and poverty reduction;
d) the impacts on the rural poor of climate variability and access to water, and the coping strategies employed to mitigate the threats at household level;
e) the role of water infrastructure in mitigating the impacts of water vulnerability.

2.3 Constraints of study

It was not the intention of this analysis to identify specific investment opportunities for the development of water resources infrastructure in Mozambique. This was primarily due to the limited resources available for the study. The study was also constrained by limitations in available information. The quantitative analysis is partial and the methodology used adopts a mixture of quantitative and qualitative methods largely determined by availability of macro-economic, agricultural, meteorological and hydrological data.

3 Background and context

3.1 Water resource overview

3.1.1 General description

The water resources situation in Mozambique compares well with the rest of the world in absolute terms. The availability per capita of surface water resources is about 5550 m^3/year (for runoff generated within the country) or 12000 m^3/year (including cross-border flows).

The majority of the rivers have a torrential regime, with high flows during 3-4 months and low flows for the remainder of the year which means that without storage these resources cannot be used. The country has 104 main river basins, out which 50 have a catchment area less than 1,000 km^2, 40 are with an area between 1,000 and 10,000km^2, 12 between 10,000 and 100,000 km^2, and 2 basins (Zambezi and Rovuma) have catchment areas in excess of 100,000 km^2. The most important river basins, from South to North, are: Maputo, Umbeluzi, Incomati, Limpopo, Save, Buzi, Pungoe, Zambezi, Licungo, Lurio, Messalo and Rovuma (Figure 1). With the exception of the Licungo, Lurio and Messalo, all major basins are shared with other countries.

The Zambezi basin is shared by a total of 8 countries. Mozambique has abundant surface water resources in terms of total mean annual runoff estimated at 216 km^3/year. The total inflow at the border is about 116 km^3/year while the runoff generated within the country is about 100 km3/year, in average. Therefore, more than 50% of the total mean annual flow is generated outside of the country. The Zambezi basin represents about 50% of the country's total mean annual runoff and 75% of the total cross-border inflow: the basin receives 88 km^3/year of inflow at the border and 18 km^3/year of the basin's runoff is generated within the country, giving a total mean annual runoff of 106 km^3/year. Groundwater resources in Mozambique are relatively modest.

3.1.2 Water Resources Variability

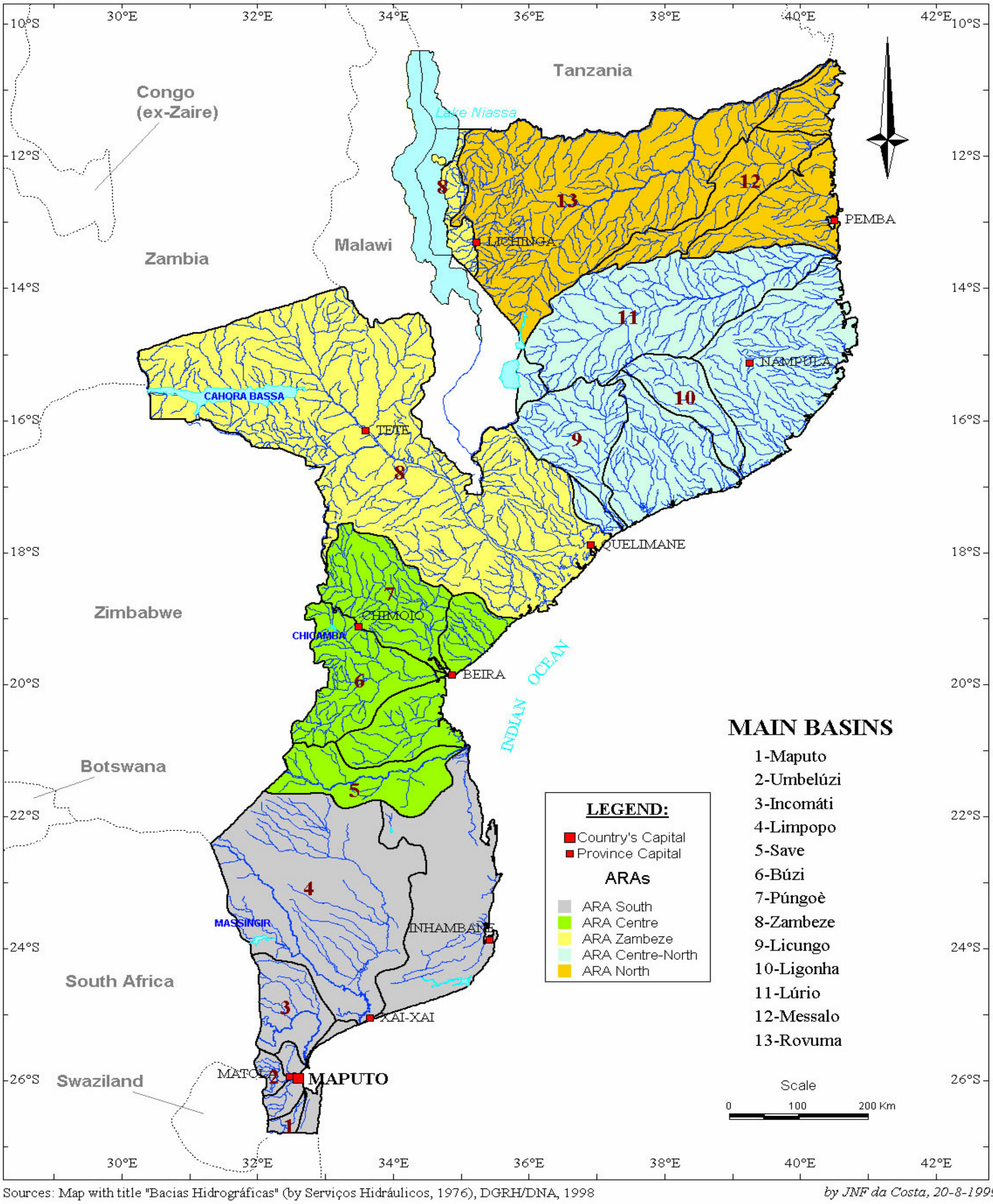
Mozambique has a highly variable climate which has a significant influence on the amount, timing, and frequency of precipitation events. Rainfall varies considerably within annual cycles with 60-80% of the annual precipitation falling in the period from December to March. The annual average rainfall ranges from over 2000 mm in Northern Mozambique to about 500 mm in the South. The variability of rainfall from year to year is also much higher in the South than in the Northern and Center regions of Mozambique with almost no flow observed in some rivers in dry years in the South.

On average Mozambique has ample water resources - if an overall water balance of each basin is evaluated, nearly all basins would show a significant surplus of annual total runoff compared to any foreseeable water demand. However, within these aggregates, serious water shortages occur during dry seasons in a number of basins, especially in the South. The minimum monthly flow is 1-2% of the annual runoff for many rivers. Without larger and small scale water storage infrastructure, these resources cannot be used to meet the demands.

Tropical cyclones and the El Nino/La Nina phenomenon compound the variability resulting in extreme floods and droughts such as the floods of 2000 in the South and 2001 in the Center of the country. However, floods and droughts are frequent in Mozambique, occurring cyclically with varying intensity. More localized droughts are observed every 3-4 years and are often not well recorded. According to the National Meteorology Institute, INAM, the intervals between extreme rainfall events are shortening, while the intensity of rainfall in these events is increasing. The years of major floods in Mozambique over the last 25 years are 1977-1978, 1985, 1988, 2000-

2001, and of major droughts – 1981-1984, 1991-1992, 1994-1995, 2002-2003. It is predicted that these conditions will be exacerbated by climate change.

Figure 1. Main River Basins of Mozambique
Source: Water Resources of Mozambique, DNA, 1999



3.1.3 International rivers

Mozambique is a downstream riparian state on all nine of its major rivers, with about 54% of the total annual runoff generated outside of the country. The high dependence of Mozambique on shared water resources is an important factor in the national water vulnerability. In the South, all major rivers (Maputo, Umbeluzi, Inkomati, Limpopo and Save) originate in neighboring countries. Significant water abstraction from these rivers in the upstream countries, along with high flow variability, reduces water availability in these basins and increases water vulnerability of the Southern region. The combined average natural flow in the four basins[2] is about 11 km^3/year – this is predicted to reduce to about 5 to 6 km^3/year over the next 20 years, and be more variable in future, due to growing demand on the resources from riparian neighbors.

Mozambique is very active in a number of joint processes with riparian countries to ensure that its interests and concerns are addressed. The management of river basins and reservoirs upstream of its territory has direct impact on its own risks, particularly related to floods.

3.2 Socio-Economic Development Context

Mozambique has made significant socio-economic progress since the peace agreement in 1992. The transformation of Mozambique’s economy in recent years due to increased political stability, introduction of a multiparty democracy, deep economic reforms and strong external financial and technical support has been impressive. Real output annual growth has averaged about 9% between 1995-2001. In real GDP per capita terms, GDP has grown by 7.5% over the five years since 1996.

Despite these achievements, Mozambique remains one of the poorest and most indebted countries in the world, suffering from acute internal and external imbalances, and it continues to be heavily dependent on foreign assistance for the delivery of basic social services. Per capita income in Mozambique, at US$210 in 2003, was below the average for sub-Saharan Africa (US$500) and the low income group (US$410). Subsistence agriculture continues to employ the vast majority of the country's workforce. The incidence of poverty in the rural areas is 71.3% compared to 62% in the urban areas[3]. The Human Development Index, an index of income, education and life expectancy, ranked Mozambique 170 out of 173 countries.

Thus, the Government of Mozambique is facing the challenge of sustaining very rapid economic growth while reducing the levels of absolute poverty. The overall national development objectives and the Government’s strategy for addressing the development and poverty issues over the medium term are set out in the “National Action Plan for the Reduction of Absolute Poverty (PARPA)”. The overall objective of the PARPA is to reduce poverty by about 30% over thirteen years, from 70% in 1997 to below 60% in 2005 and 50% by 2010.

The PARPA stresses that economic growth over the next 5-10 years must be rapid and pro-poor, and the strategy is based on an average annual growth rate of 8% for the period 2001-2010. The main sources of growth include production from identified large-scale, capital intensive projects (“megaprojects”), productivity and value-added gains in agriculture and small manufacturing, combined with encouraging labor-intensive, private sector-led manufacturing and service activities. The PARPA recommends focusing on agriculture and removing impediments to private sector development, while redirecting public spending toward sectors with the highest potential for reducing poverty, such as education, health, and basic infrastructure (roads and water supply).

[2] Excluding the Save river where water demand in Mozambique is very low.

[3] Millennium Development Goals- Republic of Mozambique, August 2002

Strong economic growth in agriculture is the most important factor driving poverty reduction. The PARPA's strategy assumes average growth of 8 % p.a. in agriculture, based on expansion in cash crops and increased production of food crops.

Attainment of these ambitious growth objectives requires a clear identification of risks and constraints that need to be carefully monitored. These risks undoubtedly include high climatic and associated hydrological variability. The IMF and IDA's Joint Staff Assessment of the PARPA[4] indicates specifically that the risk of periodic natural shocks may constrain the actual growth in output. There is growing evidence of a negative correlation between rainfall variability and real total GDP and agricultural GDP growth. Growing competing water demands from the major sectors of the economy, and specifically, agriculture, may also impose a serious constraint on the medium- and long-term growth prospects in terms of water availability in some river basins.

3.3 Role of water in key sectors

Most of the sectors which contribute to and make up the Mozambican economy are either directly dependent upon secure, sustainable water availability or are indirectly effected by water shocks (droughts or floods).

Mozambique has a US$4.3 billion economy. Agriculture produces approximately 22% of the GDP, industry (including manufacturing) produces about 33%, and services produce about 45%. All these sectors are dependent on an adequate supply of water. Agriculture (including irrigation, livestock and forestry) uses about 73% of the total water consumption, with industries using about 2% (Table 4.1). This indicates that about 75% of the water use in the country has a direct impact on economic production. Urban and rural domestic water supply uses most of the remainder (about 25% of the total water consumption) and has a direct impact on the service industries and public health.

Further analysis is needed of water demand and future trends, particularly related to the 'mega-projects' and their water needs. This will be undertaken in the Country Water Resources Assistance Strategy which will be formulated based on this Memorandum.

Table 1. Composition of Total Consumptive Water Use in Mozambique by Sector and by Region (million m^3) – 2003

Region	Domestic Water Supply	Industrial Water Supply	Irrigation	Livestock	Forestry	TOTAL
South	128	15	202			345
Center	89	4	206	66	29	394
North	73	19	230	90		393
TOTAL	290 (25.6%)	19 (1.7%)	638 (56.4%)	156 (13.8%)	29 (2.5%)	1132

Data Source: NWDP1, BB5 Phase 1 Report: Black&Veitch International, August 2004

3.3.1 Agriculture

Mozambique's poverty is closely linked to its dependence on rain-fed subsistence farming in the context of highly variable rainfall and frequent droughts. Within the framework of increasing agricultural output and reducing poverty, the PARPA and PROAGRI as the PARPA's implementation basis, emphasize the need to increase agricultural productivity, improve access to land and secure land tenure, and facilitate rural trade. About 45% of the country is considered suitable for agriculture, however, only 4 % of the total arable land is presently cultivated. In 2001 the agricul-

[4] Joint Staff Assessment of the Poverty Reduction Strategy Paper. IMF and IDA. August 2001, p.4

tural sector's share in total GDP was 22%[5]. Between 1987 and 1999 value added in the agriculture, livestock, and fisheries sectors grew at an average annual rate of more than 6 percent, accelerating to nearly 9 percent after 1996.

Broadly, there are two levels of agricultural activity, *subsistence farming* and *commercial farming* with a mixture of subsistence and cash cropping between the two levels.

Irrigation

The total cultivable area in Mozambique is estimated at 36 million ha (45% of the total area), and the irrigation potential is 2.7 million ha. Over 50% of this potential is located in the Zambezi basin, which represents 7% of the cultivable land. The existing irrigation schemes cover 120,000 ha, of which only an estimated 41,000 ha is currently operational. Close to 50% falls in the category of small-scale "family" irrigation; the remaining 50% is under private management. The main irrigation crops are rice, sugar cane, maize and citrus.

Irrigation in Mozambique can be categorized into three types;

- the large-scale irrigation schemes of the Limpopo Valley and the private sugar companies;
- small-scale irrigation, generally covering less than 100 ha; and
- micro-irrigation, usually based on treadle pumps and other manual methods.

The present situation and planned developments for each of these categories can be summarized as follows:

- *Large-scale public irrigation schemes:* The largest are the Chokwe Scheme (22,000 ha), run by HICEP (Chokwe Public Irrigation Enterprise), and the Xai-Xai Scheme (9,323 ha net, of which some 2000-3,000 ha formerly had pumped irrigation), in the Limpopo Valley. A major rehabilitation programme for Chokwe has been under way for some years and is scheduled to continue until 2006/07. Xai-Xai is to be rehabilitated under the ADB-funded Massingir Dam and Smallholder Agricultural Rehabilitation (MDSAR) Project. At present only some 4-5,000 ha of Chokwe is in operation and there is no public irrigation in operation at Xai-Xai.
- *Small-scale irrigation:* The five year ADB-funded Small-scale Irrigation Project (SSIP) started in 2002 and is expected to develop some 2,500 ha on about 650 schemes in Maputo, Sofala and Zambezia provinces. Total estimated cost is US$20 million. An Action Plan for SSI scheme rehabilitation in five other provinces and Zambezia also began in 2002.
- Unlike the two categories above, *micro-irrigation* is a purely farmer-run activity. Based typically on treadle pumps and other low-cost technologies, it is used particularly for dry season vegetable production.

Irrigation in Mozambique has an efficiency of only about 45%. Under these conditions, the water demand for irrigation is currently estimated at around 600 million m3/year (Table 2). The Government intends to double the current irrigated area in the medium term, which would be mainly achieved through rehabilitation of the existing irrigation schemes, using public and private funding. Assuming that irrigation water use efficiency will increase by 30% over the next 10 years, the projected irrigation water demand in the medium term is estimated to be close to 1000 million m3/year (Table 2).

[5] National Institute of Statistics of Mozambique (INE)

Table 2. Present (2003) and Projected (2015) Irrigated Area and Irrigation Water[6]

River Basin	Irrigated Area (ha)		Water Demand (Mm^3/year)	
	Present 2003	Projected 2015	Present 2003	Projected 2015
Umbeluzi	850	4000	13	60
Inkomati	10340	23900	155	251
Limpopo	4000	20000	60	210
Total South	*15190*	*47900*	*228*	*521*
Buzi	0	6100	0	90
Pungoe	7420	10620	111	160
Zambeze	7880	10500	95	126
Total Center	*15370*	*27220*	*206*	*376*
Ligonha	4500	7470	67	78
Messalo	0	0	0	0
Total North	*11860*	*17990*	*178*	*189*
Lichinga	7360	10520	110	110
TOTAL	42420	93110	636	918

Livestock
Livestock is of less importance than in neighboring countries and cattle numbers, in particular, fell drastically during the civil war. In the early 1970s the cattle population was about 1.4 million head, double the 0.72 million head recorded in the 1999/00 Census. The much larger goat population (5.05 million) is more evenly distributed. From the viewpoint of water resources, at present the demand for water for livestock production is not significant, although some modest increase in the demand can be foreseen in the medium term.

Forestry
There are about 62 million hectares of natural forest in Mozambique, corresponding to 78% of the national territory. This includes forests of varying composition, density and volume. Some 5 million ha of Mozambique's land area is classified as dense forest and 15 million ha as open forest (i.e. miombo woodland). There are also some 0.4 million ha of coastal mangroves. Forest production is based almost entirely on the natural forest, the area of plantation forestry being negligible. In addition to widespread exploitation for domestic wood fuel, commercial timber production is of considerable economic importance.

3.3.2 Hydropower

Hydropower generation is one of the most important non-consumptive water users in Mozambique. Mozambique has one of the lowest electrification rates in Southern Africa (approximately 5%). However, the gross national electricity consumption has increased substantially as several mega projects have been implemented. The construction of a new aluminum smelter, Mozal, has increased the national energy consumption three fold since 2002. However, the domestic electricity consumption still remains very low at 78kWh per capita (in South Africa it is 3,745kWh per capita). Only 200,000 households are connected to the electricity network (Electricidade de Mocambique (EdM – the State power utility), Annual Statistical Report, 2002).

The country has four major hydropower stations at the Cahora Bassa, Chicamba, Mavuzi and Corumana dams for the production of electricity (Table 3). Actual power demand is about 240 MW (2002), with an annual energy consumption of 1300 GWh. 80% of the current energy production in Mozambique comes from the Cahora Bassa hydropower plant (HCB) with an installed capacity of 2075MW, most of which is exported. In the coming years EdM expects to cover the

[6] The estimates are based on the following sources: NWDP1: WRMS, Building Block 4 (2004); NWDP1: WRMS, Preparation materials for Building Block 5, 2004; Interviews with staff of Agricultural Hydraulics Department of MADER (July and October 2004); National Irrigation Development Plan (1993); Joint Incomati Basin Study (2002)

demand growth from additional power allocation from the HCB and with the surplus still to be exported to South Africa, Zimbabwe and Malawi.

Table 3. Existing Hydropower Stations

Hydropower Stations	Power (MW)	Turbine		Location	
		Head (m)	Discharge (m^3/sec)	Province	River Basin
Cahora Bassa	2075	120	2000	Tete	Zambeze
Chicamba Real	34	50	60	Manica	Buzi
Mavuzi	48	160	23	Manica	Buzi
Corumana	16.6	36	25	Maputo	Incomati

Source: Water Resources of Mozambique, DNA, 1999

Potential hydropower generation in Mozambique is quite large. According to EDM, about 13000 MW, producing 65000 GWh/y of energy, can be economically developed in Mozambique. About 70% of this potential (10000 MW, 45000 GWh/y) is concentrated in the Zambezi watershed, and most of it on the Zambezi river.

3.3.3 Urban and Rural Water Supply

Figures for the levels of water supply services to rural and urban populations differ depending on how they are measured - the PARPA indicates that approximately 40% of the rural population and 44% of the urban population have access to an adequate water supply. These include only official schemes and do not count informal vending, illegal connections, etc. According to the household surveys (IAFs), access to clean water in rural areas was raised from 12 percent in 1996/7 to 27 percent in 2002/3, and in urban areas from 56 percent in 1996/7 to 64 percent in 2002/3. These sets of numbers are not necessarily in contradiction; they measure different parameters. Currently, production capacity of water supply systems for the 13 main cities, with a total about 4 million inhabitants, is about 250,000 m3/day (or a total production of about 80 Mm3/year). About 75% of this production is serving the Maputo area, with a consumption of about 50Mm3/year (mainly from the Umbeluzi river, regulated by the Pequenos Libombos dam)[7]. Most of the urban water supply relies on provision of surface water. Only five main cities – Pemba, Tete, Xai-Xai, Quelimane and Chokwe – rely on groundwater supply.

The provision of safe and reliable domestic water supply to the urban and rural population is one of the Government's main development priorities. It is estimated that urban drinking water demand, with increased per capita availability, reduced losses, projected increase in the urban population and increased coverage in the service, may reach about 250 hm3/year in total by 2015[8]. In most cases, the water production increase can be obtained from small local intakes or reservoirs. However, in case of Maputo and Beira, the increase in water supply is likely to require larger scale infrastructure solutions. This may include, in case of improving water supply to Maputo, the construction of Moamba Major dam on the Incomati river, and, in case of water supply to Beira, the construction of the Bue Maria dam on the Pungue river, which would also provide water to the planned irrigation expansion in the downstream.

3.3.4 Industry

Mozambique has three "mega-projects" – the Mozal aluminum smelter, the Cahora Bassa hydroelectric plant and Sasol gas – and several more are planed for implementation in the period to 2010. The mega-projects are intended to boost economic activity, raise manufacturing outputs, improve the trade balance, as well as increase government revenue. The completed mega-projects are major contributors to exports providing currently about 50% of overall exports, and it

[7] NWDP1: BB4 – Water Resources Development. Phase 1 report, August 2004
[8] NWDP1: BB4 – Water Resources Development. Phase 1 report, August 2004

is estimated to increase to 80% by 2010. The manufacturing sector remains a small part of the economy. Food and beverages constitute over 38% of the manufacturing production, with the aluminum production of Mozal accounting for the remaining 23%. Such manufacturing sub-sectors as textiles, garments, and footwear have not grown significantly in the face of increasing international competition.

Mozambican industries are concentrated in the country's major cities – Maputo, Matola, Beira and Nampula, and their water supply almost exclusively relies on the existing urban water supply systems. No accurate information is available on water consumption by industries, however as the country pursues its industrialization policy, it is expected that there will be increased demand for water to meet the production requirements. For Maputo the current consumption is estimated in the order of 10,000m3/day. It is expected that this water consumption will double in the short term with construction of new planned industries such as Mozal 3 and the MISP (Maputo Iron and Steel factory). Currently, Mozal uses 50,000 m3 of water per month and has requested a guarantee supply of up to 75,000 m3/month in the future to meet the needs of the extended Mozal 3 project. Provision of high value water for industry should be a high priority which requires further analysis.

3.3.5 Mining

The PARPA notes that the mining sector has a considerable development potential, specifically, in raising incomes amongst poor segments of the population. However, the sector has received a limited development in the post-war period. The major coalmine at Moatize stopped production during the war but may be reopened shortly with assistance from foreign investments. Mining accounted for only 0.2% of GDP in 1999. Natural gas resources are currently being developed in the south of the country. The construction phase of a gas pipeline between the Pande and Temane gas field in the southern Inhambane province and Secunda in South African began in May 2002. The pipeline will supply gas to the large South African market. There is no information available regarding the demand for water from the mining and minerals sector. It is expected that the demand will grow with the revitalizing of the sector, particularly in exploration of marble at Montepuez and gold in Manica and Niassa provinces, and reopening of the Moatize coalmines in the Tete province. Water is an important input in both manufacturing and industrial processes. In addition to ensuring adequate supply of water for manufacturing and industrial processes, it is essential that industrial and manufacturing effluent does not pollute the country's water resources.

3.3.6 Environmental Use of Water

The environment uses water to sustain river health and ecological functions. In order to preserve an acceptable balance within a specific watercourse, it is necessary to ensure that an adequate ecological reserve is maintained in the river basin – the reserve refers to both the quantity and quality of water in the river. The ecological reserve of water ensures the ecological integrity of rivers, estuaries, wetlands and groundwater resources. Water allocated to the environment (and to some extent to hydropower) is also used for recreational activities. Recreational use of water in Mozambique is expected to increase due to the Government's policy on development of tourism industries. In Mozambique, there are currently 34 nature conservation and protection areas, covering more than 10% of the country's total area. These biodiversity rich areas are under threat from unsustainable use of natural resources, including water resources. The environmental requirements for water, in quantitative and qualitative terms, need to be developed for each river basin in Mozambique and the environmental reserve needs to be protected.

3.4 Government Water Infrastructure Development Strategy

The Department of Water Affairs (DNA) of the Ministry of Public Works and Housing is in the process of developing a National Water Resources Management Strategy (as a component of the

IDA financed National Water Development Project I). A recent draft report[9] defines priorities for the development of water infrastructure and management which are designed to meet the development needs of the various sectors. **It must be noted that these plans are tentative and have not been adopted by the Government at the time of writing. The plans have also not been assessed in detail by the World Bank – they are used for indicative purposes only.** Key elements of the proposed WRM Strategy include the construction of dams and reservoirs in all regions to provide secure sources to urban centers and rural needs including irrigation; the development of hydropower and flood control. The costs of the proposed public investments in water management and infrastructure are summarized in Table 4:

Table 4. Proposed Public Investments in Water management Infrastructure (2005-20025)

Type of Investments/Activities	Location	Completion	Est. Costs (US$ m)
Flood Protection			
Dykes construction and rehabilitation	Xai-Xai, Chokwe, Save and Buzi basins	By 2015	200
Early Warning System		By 2015	50
Studies on operational rules of existing reservoirs		By 2015	20
Total			**270**
Irrigation Rehabilitation	South region	By 2015	**100**
Small Irrigation developments	Center, North	By 2015	**20**
Hydropower development	Zambezi	By 2015	**50**
Basin Master Plans	Incomati, Maputo, Zambezi, Pungwe, Buzi	By 2015	**9**
Inventory of existing hydraulic structures		2008	**4**
Dams and Transfer works			
Moamba Major dam and pipeline	Incomati River		265
Bue Maria Dam	Pungwe river	By 2015	150
Third large dam (possibly Mapai)	Limpopo (possibly)	2015-2025	150
Medium size dams for irrigation	Center, North	By 2015	30
		2015-2025	15
Total			**610**
TOTAL		By 2025	1063
		By 2015	899

Data Source: NWDP1, BB4 Phase 2 report. COBA/Consultec, 2004

3.5 Water Sector in the National Budget

The PARPA clearly acknowledges the importance of water infrastructure development as an essential factor for the rapid expansion of economic activities, and thus for the reduction of poverty. The Water Programme of the PARPA identifies such priority areas in water resources management as sustainable use of water and construction of new small and medium size dams; building infrastructure for irrigation and development of water management schemes with additional water storage facilities to mitigate the negative impacts of droughts and floods. ***However, the water resources management sector remains chronically underfinanced and continues receiving low priority in the government spending program.***

Total water sector public expenditure was some US$15.1 million in 1999, almost doubling to US$28.1 million in 2000 and then falling back to US$24.3 million in 2001 (Table 5)[10]. On average, this was equivalent to some 0.6% of GDP and was mostly provided by donors. The level of Government funding remained fairly constant, at between US$4.2 million and US$4.7 million.

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[9] Building Block 4 – Water Resources Development. NWDP1, Phase 1 and Phase 2 Reports. COBA/Consultec, 2004. These proposals have not been reviewed by the World Bank.
[10] Background Paper on the Water Sector by Finney and Kleemeier. Mozambqiue Public Expenditure Review, World Bank, 2003

In 2001 water sector expenditures represented 2.5% of the government investment budget (excluding donor funds). Total sector spending rose considerably because donor financing increased significantly in response to flooding. Even at its height, though, spending never reached the annual levels of between $85 and $108 million planned in the revised PARPA budget for 2002-04. Government expenditures in other PARPA priority sectors were much higher in the same year: the spending for roads amounted to 19.7%, for education 12.8%, and for health 10.6%. The water supply and sanitation sub-sector accounted for almost all expenditures in the water sector in 2001. ***In 1999, 2000 and 2001 annual expenditures on the water resources sub-sector accounted for only 2.1%, 1% and 1.45% respectively of the total spending in the water sector (including donor financing).***

Table 5. Government and Donor Expenditure in the Water Sector, 1999-2001

Type of Expenditure (U.S. $ millions)	**1999**	**2000**	**2001**
Government Recurrent	$1.90	$1.77	$1.91
Government Capital	2.80	2.43	2.73
Government Total	4.70	4.20	4.65
Donors	10.40	23.88	19.68
Total	15.10	28.08	24.33
Govt. as % of Total Sector	31%	15%	19%
Water Supply and Sanitation as % of Total Sector	90%	97%	83%
Water Resources Sector:			
Government Recurrent	0.282	0.269	0.321
Government Capital	0.038	0.023	0.029
Government Total	0.319	0.292	0.350

Notes: *Government expenditures under the national investment budget only. Donor expenditures as reported to the Ministry of Planning and Finance (may therefore be incomplete). "Recurrent" refers to costs and materials for project staff. Exchange Rates Meticais=USD 1 as follows: MT12,691 (1999), MT15,689 (2000), MT20,707 (2001)*
Source: *Adopted from Finney, Kleemeier. Background Paper for Mozambique PER, World Bank, 2003*

In late 2001 the DNA proposed a revised PARPA budget for the period of 2002-2004 (Table 6). The revised budget gave substantially less priority to rural and urban water supply, and almost doubled the amount allocated to water resources. However, it must be noted that the PARPA figures are what the water sector would like to have by way of allocation – not what they actually received. The proposed budget significantly exceeds the level of funding provided for in the General State Budget for 2002-2006 which allocated only about USD20 million for the entire water sector (including donor funding).

Table 6. Revised PARPA Water Program Budget, 2002-04

Sub-sector	US$ millions				Percent
	2002	2003	2004	Total	
Rural water supply	13.7	14.9	16.5	45.1	16.0
Urban water supply	36.0	36.3	35.0	107.3	38.2
Sanitation	2.5	2.6	2.7	7.8	2.8
Water resources	30.4	32.1	52.6	115.0	40.9
Institutional development	2.4	2.2	1.4	6.0	2.1
Total	85.0	88.1	108.1	281.2	100.0

Source: *Finney, Kleemeier. Background Paper for Mozambique PER, World Bank, 2003*

4 Water related impacts

4.1 Introduction

The background information provided above is substantial although insufficient for a detailed quantitative analysis. Notwithstanding this, there are a number of points which are self evident to most observers with even a basic knowledge of Mozambique. The objective of this study is to clarify the linkages between water, the economy and poverty. This section examines the consequences of the climatic and hydro-geographical circumstances of Mozambique in relation to the demands of a developing economy and the requirements to reduce poverty. The issues addressed are:-

i. the determination of water yields at different scales,
ii. the current under-development of water infrastructure,
iii. the impact of water shocks,
iv. the hidden costs to the rural poor,
v. a provisional economic analysis of investments planned by the Government and water resources development, and
vi. management and protection options.

4.2 Determining water yields at different scales

> **Box 1. Water Yields**
>
> The yield from a water resources system is the volume of water that can be abstracted at a certain rate over a specified period of time. In case of the typically large fluctuations in stream flow in many Mozambique's rivers, the highest yield that can be abstracted at a constant rate from an unregulated river is equal to the lowest flow in the river. By regulating stream flow by means of dams, water can be stored during periods of high flow for release during periods of low flow. This increases the rate at which water can be abstracted on a constant basis and, consequently, the yield. The total yield locally available included the yield from both local surface water and groundwater resources, as well as contributions to the yield by usable return flows from the non-consumptive component of upstream water use in the area under consideration. Total water available for consumptive use includes the total local yield plus water transferred from elsewhere. Usable water is also clearly dependent upon other competing demands and the needs for environmental sustainability.
>
> The water yield estimates quoted in this report are based on present levels of infrastructure development, annual runoff patterns of 2003 and 98% of water supply assurance.

As has been stated previously in this report, Mozambique has substantial water resources, however these resources vary across the country (wet north – dry south), vary significantly from season to season and vary from year to year with occasional extreme events of floods and droughts. If an overall water balance of each basin is evaluated, nearly all basins would show a significant surplus of annual total runoff compared to any foreseeable water demand. However, within these aggregates and in the absence of adequate storage, serious water shortages occur during dry seasons in a number of basins, particularly in the South. Water shortages in Mozambique are localized and highly seasonal. The minimum monthly flow is 1-2% of the annual runoff for many rivers. Because of this variability and very limited infrastructure, only a fraction of total runoff can be utilized. High variability means that the amount of usable and available water resources depends heavily on the development of storage and diversion infrastructure. For example, a study undertaken under the NWDP1[11] suggests that, at present level of water infrastructure development, safe yields in the most water-vulnerable South constitute about 17%

[11] NWDP1, Water Resources Management Strategy, Building Block 5, Phase 1- Inventory and Resources Assessment. Black&Veatch International, August 2004

of the total runoff in the Limpopo, 35% - in the Maputo and Incomati, and 49% - in the Umbeluzi. Looking to the future, economic development pressure is likely to make the problem of seasonal water shortages even more critical.

As demonstrated in Table 7, the projected water demand in the economically most developed South and the Center of the country would lead to negative water balances in such river basins as the Umbeluzi, Limpopo and Buzi, given the present level of water infrastructure development in these basins. To satisfy the future water needs to support the envisaged economic growth and sectoral development, safe water yields in the potentially water scarce river basins will need to be increased which can only be achieved be providing storage.

It must be noted that the figures in Table 7 are at basin scale. At sub-basin level the situation is substantially different. For example, although the situation in the Zambezi River Basin would appear at basin level to have more than adequate water resources (supply substantially exceeds demand) this only applies to the main stream of the river. The Zambezi River Basin occupies a very large area of the country, much of which for all practical purposes does not have access to the main stream of the river. **Therefore, in all basins (but particularly in the dryer central and southern regions of the country) the bulk river basin scale water yield figures present an overly optimistic picture. The smaller the catchment, the greater the vulnerability to localized rainfall variability. This is particularly important when considering safe yields of water to small scale agriculture and the rural poor.**

Table 7. Water Demands and Water Balances in the South and Center Regions in 2015, million m^3

River Basin/Region	Mean Annual Runoff	Water yields 2003	Water Demand 2015 (Mm3) Irrigation	Livestock	Water Supply (Domes&Munici	Large Industries	Forestry	Environmental Flow	Total Water Demand	Water Balance
South										
Maputo	3800.0	1331.0	60.0	0.1	6.0			930.0	996.1	334.9
Umbeluzi	296.0	144.5	60.0	0.1	162.2			44.4	266.7	-122.2
Incomati	2677.0	908.3	251.0	1.2	4.6	17.3		401.6	675.6	232.7
Limpopo	5773.0	1003.6	210.0	4.5	59.7			866.0	1140.2	-136.6
Save	n/a							0.0	0.0	0.0
Total South	**12546.0**	**3387.3**	**581.0**	**5.9**	**232.6**	**17.3**		**2241.9**	**3078.6**	**308.7**
Center										
Buzi	6420.0	1031.6	91.5	12.0	20.4			993.9	1117.8	-86.2
Pungue	3375.0	1000.3	159.3	12.0	30.2	3.0		680.1	884.6	115.7
Zambesea	106000.0	28912.3	126.0	41.0	89.2	5.0	47.0	15900.0	16208.2	12704.0
Total Center	**115795.0**	**30944.1**	**376.8**	**65.0**	**139.8**	**8.0**	**47.0**	**17574.0**	**18210.6**	**12733.6**

4.3 Under-development of water infrastructure

As noted above, amongst the very limited options to increase the safe yield of water resources is the development of infrastructure to store and / or transfer water. At present, despite the high vulnerability of Mozambique to frequent droughts and floods, the *storage capacity* in the country remains underdeveloped (as does other flood control and drought management water infrastructure). Mozambique has 12 major dams with a total capacity of about 3457 m^3 per capita, including the Cahora Bassa storage. Excluding the Cahora Bassa Lake, which accounts for more than 90% of the country's storage capacity, the storage capacity per capita in Mozambique is only 330 m^3, placing Mozambique among the Southern African countries with least developed water infrastructure. The total useful storage capacity represents 21% of the mean annual flow of the country's rivers (including Cahora Bassa). If the Cahora Bassa is excluded, the remaining 5800 Mm^3 of useful capacity represents only 5% of the mean annual runoff of the country's rivers, excluding the Zambezi. In general, storage capacity of 10-40% of the mean annual runoff is necessary to utilize 50% of the mean annual flow, with 80-90% reliability.

The Cahora Bassa dam was constructed for a single purpose – the generation of hydropower at a remote location on the Zambezi, and its operational rules do not allow its storage capacity to be used for effectively mitigating water shocks. To convert this dam into a multi-purpose reservoir to be used for seasonal water supply, etc. would be costly because of the remoteness of the site. The use of the dam for the mitigation of floods in the Zambezi valley needs serious investigation and would be in conflict with its current primary purpose of hydropower generation. Future water storage infrastructure should be developed as multipurpose facilities in the basin-wide context. Despite the driving force for power, the need for flood control, salinity repulsion, development of irrigation, and environmental requirements favors multipurpose reservoir development.

4.4 Costs of water shocks

The consequences of the climatic realities which exist in Mozambique, as described in Section 3.1.2 - *Water Resources Variability*, are frequent and recurrent water shocks in the form of floods and droughts. Each such event has considerable direct and indirect costs to the country. These have been determined in a variety of studies – one of the primary objectives of this study, however, is to examine the economic impacts and consequences of these shocks.

Table 8. Major " Water Shock" Events in Mozambique since 1980

Year	Type of Event	Details
2002-2003	Drought	43 districts affected in South and Central provinces
2001	Floods	Zambezi river; 115 deaths; 500,000 people affected
2000	Floods	Limpopo, Maputo, Umbeluzi, Incomati Buzi and Save river basins, caused by record rainfall and 3 cyclones; 700 deaths, 2 million people affected
1999	Floods	Floods in Sofala and Inhambane provinces; highest rainfall level in 37 years; EN1 major country highway shut for 2 weeks; 100 deaths; 70,000 people affected
1997	Floods	Floods on Buzi, Pungue and Zambezi rivers; no road traffic to Zimbabwe for 2 weeks, 78 deaths; 300,000 people affected
1996	Floods	Floods on all southern rivers of the country; 200,000 people affected
1994-1995	Drought	1.5 million people affected in South and Central parts of Mozambique. Cholera epidemic.
1991-1992	Drought	Whole country affected. 1.32 million people severely affected. Major crop failure.
1987	Drought	8000 people affected in Inhambane province.
1985	Floods	Floods in Southern provinces; 9 rivers floods; worst flooding in 50 years followed by 4 years of drought; 0.5 million people affected
1983-1984	Drought	Most of country affected. Cholera epidemic and many deaths from drought and war.
1981-1983	Drought	2.46 million people affected in South and Central parts of Mozambique.
1981	Floods	Floods on Limpopo river; 0.5 million people affected
1980	Drought	Southern and Central parts of Mozambique affected

Sources: INAM; Atlas for Disaster Preparedness and Response in the Limpopo Basin, INGC, UEM-Department of Geography and FEWS NET MIND, 2003

4.4.1 Flood costs

The costs of floods can be categorized as follows:-

- Direct costs of physical damage to capital assets and inventories, valued at same-standard replacement costs (i.e. the costs for restoring assets to the standard that existed before).
- Indirect costs of output losses and foregone earnings referred to as 'flow effects'.
- Relief costs including (i) the provision of life-supporting services (e.g. food aid, health care, safe water and sanitation) to populations whose access to these services has been lost as a result of the disaster and (ii) assistance to these populations to enable them to resume sustainable livelihoods.
- Reconstruction costs of rebuilding damaged infrastructure to standards optimally designed to reduce vulnerability and risk of loss due to future potential disasters (i.e. the costs for rebuilding to a standard that optimally responds to local conditions, including the risk of natural disaster).

The costs of the 2000 floods were estimated as USD550 million including the direct, indirect, and disaster relief costs.

4.4.2 Drought costs

Hydrological drought refers to the deficit in the runoff of rivers. The impacts of significant deficits in the total annual runoff may include reduction in hydropower production and negative affects on irrigation relying on reservoirs and surface water. Hydrological droughts also affect urban water supply. This was particularly felt in the city of Maputo, in the beginning of the 1980s, before the construction of the Pequenos Libombos Dam, and very acutely in Beira and Chimoio in 1991-92. Examples of impacts of hydrological droughts are given in Table 8.

Drought risks are a major concern for agriculture in the southern provinces of Inhambane, Gaza, and Maputo, with the exception of the coastal districts. Drought also frequently affects the central province of Tete. Some districts are faced with both drought and flood risks (Matutuine, Chibuti, Moatize, Cahora Bassa). Impacts include agriculture, livestock and rural water supply. Since independence in 1975 Mozambique has experienced many severe droughts. During the cropping years 1982/1983, 1986/1987 and 1991/1992, maize yields fell on average by 40% and by 85% in the center of the country (Tete and Manica provinces).

Such dramatic events caused large-scale food deficits, hunger and disease. It also increased food imports and worsened the national debt burden. The devastating drought of 1991-1992 halved cereal production, more than doubled cereal import requirements and raised food aid import to 4 million tons for the Southern African region[12].

It is estimated that the loss in agricultural production due to the drought 1992 was 4 percent of GDP[13] or about US$86 million in 2004 prices. These cost estimates seem to be conservative. Although drought effects in Mozambique mainly concentrate in the agricultural sector, drought impacts also include forest fires, losses related to damaged water supply for domestic and industrial use and associated indirect losses, including social and environmental impacts. It is difficult to estimate the cost of drought shocks in Mozambique with any precision because physical impacts beyond food security effects are normally not well recorded.

[12] Arndt C., M. Bacou, and A. Cruz. Climate Forecasts in Mozambique: An Economic Perspective. In: Coping with Climate Variability: The Use of Seasonal Climate Forecasts in Southern Africa. Ed. K. L. O'Brien, C. H. Vogel, Ashgate Publishing, England, 2002

[13] M. Bacou. Economy-wide Effects of Climate Variability and Climate Prediction in Mozambique. Msc. Thesis, Purdue University, 2001

4.5 Economy wide impacts of water shocks

4.5.1 Economy wide effects of floods

The economy wide effects of floods are very wide and pervasive – in addition to the direct costs as described in the section above, the economic effects include factors such as lost production, intermediate product costs and purchasing power reductions, and disincentives to investments at all levels.

Water shocks also have potentially important implications for the budgetary and trade balances and often cause adaptation changes in monetary and fiscal policies to respond to shock-induced inflation, increased budget expenditures on relief and reconstruction, pressures to increase subsidies and diminished revenues due to lower than projected economic growth. The floods of 2000-2001 provide an example of an adverse impact of shocks on the budgetary balance of the country. Due to a prudent fiscal approach accompanied by substantial external assistance, the budget deficit after grants was relatively low until 2000 (it rose from 1.5 percent of GDP in 1999 to 6 percent in 2000 and 6.6 percent in 2001). Combined with a careful monetary policy, especially in the period 1996 to 1998, and a program of structural reforms based mainly on privatization, tax and customs reform and trade liberalization, this resulted in low inflation, high private investment and high growth rates.

The sharp increase in budget deficit in 1999-2002 was due in significant part to banks restructuring and the increase in the civil service wage bill of 46 percent in real terms between 1999 and 2002[14]. However the budget deficit before grants excluding the banks restructuring and wages increase factor, rose from 10.9% in 1999 to 17.6% in 2001. Therefore, a significant portion of the total increase in the budget deficit in 2001 can be attributed to the flood impacts and, specifically, to the increased public expenditures on post-flood reconstruction. Even with high levels of external grants and foreign net borrowing, domestic borrowing was impacted significantly in the period 1999 to 2002.

Table 9. Domestic Borrowing for the period 1999 - 2002

Year	Domestic borrowing as % GDP
1999	-0.3
2000	0.8
2001	1.8
2002	2.1

Note that the incentives to finance disaster prevention can be perverse in that non-fungible humanitarian assistance is often available for floods/droughts (as was the case after the floods of 2000 and 2001) which may promote a fiscal strategy to under-invest fungible development funds in disaster prevention. However, the budgetary impacts in the aftermath of extreme events such as the 2000 – 2001 floods remain considerable even with the relatively large non-fungible humanitarian assistance received.

4.5.2 Economy wide effects of droughts

A simple assessment of sensitivity of the Mozambique economy to water shocks measured by fluctuations in GDP and growth rates of agricultural and non-agricultural sector products, demonstrates that major floods and droughts have a significant impact on the country's economic performance. The analysis highlights that almost all major volatilities in this still largely agricultural

[14] Mozambique Public Expenditure Review. World Bank, 2003: p. 19

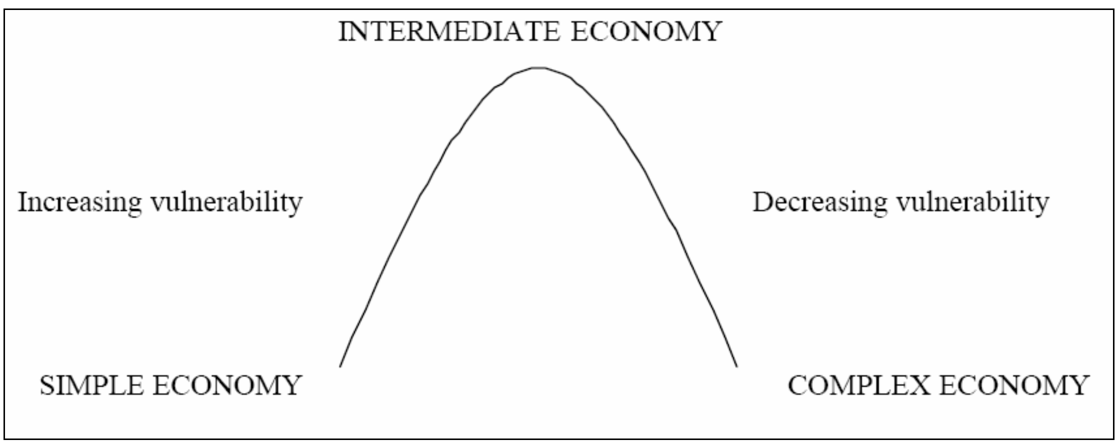
economy in the period 1984-2002 were linked to flood and drought extreme events. With the exception of the 1987 drought[15], all major droughts and floods during that period resulted in downturns in the agricultural and total GDP annual growth rates.

For example, the shocks of the floods of 2000 led to the abrupt fall of the GDP growth rate to 1.5% in 2000 (during the period of 1994-2003 the annual average growth rate was 7.5%). Also, in 2000, agricultural output experienced negative growth of 10.8%. The decline in the agricultural growth rates in 1990-1992 seems to correlate with drought conditions in the same period. In 1990 the agricultural output declined by 3% and fell to a negative growth of 4 % in 1991. The trend continued during the severe drought of 1992 that contributed to negative growth rates of 18.2% of agricultural GDP and 8.6 % of total GDP in 1992. The drought of 1994-1995 resulted in a negative growth rate of agricultural output of 6.4% in 1994 and the slowing down of total GDP growth from 7.5% in 1994 to 4.3% in 1995.

4.5.3 Immediate impact and post-shock economic recovery

Studies based on multi-country comparisons and historical observations[16] demonstrate that economic sensitivity to climatic shocks is highly dependent on a country's *stage of economic development.* Semi-subsistence economies with large agricultural sectors like Mozambique are particularly vulnerable to drought shocks, reacting immediately with a decline in GDP, agricultural exports, employment opportunities, domestic purchasing power, rural poverty level and negative impacts on the budgetary balance. At present, for a largely rural economy such as Mozambique, wide macro-economic effects of water shocks, and, specifically, droughts, are mainly felt through their direct impact on the agricultural sector.

Figure 2: Changing drought vulnerability as economies develop



Source: Benson & Clay, 2001

The remainder of the economy tends to be less impacted than the agricultural sector because of the weak inter-sectoral linkages. The growth rates in industrial production and services have not been very sensitive to the climate variability extremes. With development of the manufacturing sector and stronger overall economic integration, the impacts of water shocks would be dispersed more extensively throughout the economy. Greater development of manufacturing or simple

[15] As noted in the World Bank 2001 Mozambique Economic Memorandum, the economic comparisons during the 1980s should be taken with caution because national accounts during that period included weak estimates of smallholder agriculture and services. A vast amount of economic activity was unrecorded in official sources, and the accuracy of statistical information was poor and uneven.
[16] Benson C. and E. Clay. 1998

products from domestic raw materials (e.g. textiles, food), further economic diversification and growth of urban population more dependent on purchased food, would be likely to increase the vulnerability of the Mozambique economy to water shocks. However, in the long-term, the relative vulnerability is expected to decline in an "inverted U" relationship whilst the economy is moving from an "intermediate" to a "complex", stage of development which is much less dependent on the agricultural sector[17].

Because of the simplified sectoral needs and weak links of other sectors to agriculture, *after-shock economic recovery* may also occur relatively quickly, assuming the timely availability of necessary agricultural inputs. After the 1991-1992 drought, agricultural and total GDP growth had been restored to the remarkable rates of 21% and 8% respectively already in 1993. However, despite this strong resilience of the Mozambique economy to meteorological shocks, droughts and floods impose a significant and systematic economic threat, affecting the country's long-term growth.

The limitations of this analysis need to be borne in mind - the human vulnerability of the subsistence-based economies is downplayed. Whilst in simplified economies the quantified economy-wide impacts of water shocks may be less, more people are likely to be directly and catastrophically impacted as the family level poverty coping strategies, which are finely balanced in the best of times, are undermined and overwhelmed resulting in greater numbers of people falling into absolute poverty. These consequences are hidden in this analysis.

4.5.4 Long-Term Costs of Water Shocks

Floods and droughts are frequent in Mozambique, appearing with a higher or lower intensity almost each three-four years. A drought shock with severe impacts has occurred seven times over the last 24 years (about once in 3-4 years). Floods have occurred six times over the same period, about once each 4 years. The costs of the flood damage and major drought events estimated above occurred from the exceptionally severe 2000 floods and 1991/1992 droughts. However, it is reasonable to assume that 1-in-3-or-4 year droughts are typically 50 percent as severe as the 1992 drought, and 1-in-4 year floods would be 40 percent as severe as the floods of 2000. That means that, on average, Mozambique experiences floods that cost about US$240 million[18] each 4 years and droughts that cost it about US$45 million every 3-4 years. This translates to a direct long-term fiscal liability of over US$70 million annually. The total costs of water shocks in the period 1980-2003 were about US$1.75 billion.

A regression analysis undertaken in the recent World Bank study[19] over the period 1981-2004, suggests that in Mozambique GDP growth is cut by 5.6% in average when a major water shock occurs. ***Assuming the rate of the major disaster occurrence as one in five years, on average GDP growth in Mozambique is reduced by 1.1% annually due to the impacts of water shocks.*** This estimate translates to a US$711 million loss in total GDP over the last 24 years. The future costs to the national economy, if no measures are taken, will be much higher: assuming a 5% annual GDP growth, by 2030 the total economic costs due to floods and droughts will reach the amount of about US$3 billion.

A provisional indicative economic analysis was conducted on the investment proposals which have been suggested to the Government through the National Water Development Program I

[17] Benson C. and E. Clay. The Impact of Drought on Sub-Saharan African Economies. Technical paper 401, World Bank, 2001
[18] All costs quoted in this section are in constant 2004 prices.
[19] M. Benito-Spinetto, P. Moll. CEM Background Paper "Macroeconomic Developments, Economic Growth and Consequences for Poverty". World Bank, Africa Region, PREM 1. December 2004

strategy development process. (See Appendix 1) Whilst these proposals have not been adopted formally by the government at the time of preparation of this study, they provide an indication of the type and cost of investments required to meet the country's need over the next few decades. The analysis of these proposals was undertaken to provide an initial assessment of whether the proposed investments in the water resources sector are likely to be economically viable.

The analysis was based on simplified assumptions about the expected value of benefits and their distribution in time. The proposed package of investments has multiple objectives to improve flood protection, reduce the impact of droughts through expanded irrigation and increase hydro-power production. The calculations assume that the year-on-year cost to the economy of water shocks (1.1% of GDP) will be reduced by 75% as a result of the investments. It is clear that no amount of investment can completely protect a country from extreme events. The figure of 75% mitigation is high but the initial analysis does not include the additional economic benefits of improved water supply for urban and industrial consumption, improved rural supply, increased agricultural output and hydropower production.

The initial, indicative analysis shows that the possible package of water sector investments is economically viable, taking into account only the value of the mitigation benefit and based on the assumptions made of mitigation benefits. This result is only of initial indicative value - a detailed analysis of the investment components and all the economic, social and environmental costs and benefits will be undertaken as a key element of the next stage of the preparation of a Country Water Resources Assistance Strategy. The questions which needs to be answered are :-

- **What investments are required to reduce to impact of water shocks on the Mozambican economy by 75%?**
- **How should the next dollar be spent in water resource development for the highest strategic return?**

4.6 Hidden costs to the rural poor

Some 70% of the population of Mozambique rely upon subsistence agriculture for their livelihood which places the majority of the population outside of the monetary economy of the country. The costs to this segment of the population of recurrent water related shocks and underdevelopment remain therefore largely unrecorded and outside of the reckoning of costs of these events at national level.

Mozambique's poverty is closely linked to its dependence on rain-fed subsistence farming in the context of highly variable rainfall and frequent droughts. Rainfall conditions strongly influence food security across the country, as subsistence agriculture is the most dominant form of livelihood, providing more than 80% of basic food needs to more than 70% of the population. Livelihood options outside agriculture are limited for the great majority of the population. The marketing network is weak and limited by extremely difficult physical access to many areas. All these factors increase vulnerability of the rural economy to the rainfall variability and related water shocks such as droughts and floods. Rural households are particularly susceptible to droughts due to the self-provisioning nature of the farming and weak marketing infrastructure. An IFPRI study[20] shows that home consumption accounts for 65% of total agricultural production valued at producer prices (i.e. excluding marketing margins and consumption taxes) and represents about 23% of total household consumption of commodities. A large part of home-consumed production is due to safety-first considerations because of high expectations of food security problems ac-

[20] Arndt C., H.Tarp, S. Robinson. Marketing Margins and Agricultural Technology in Mozambique. IFPRI, Washington DC, July 1999

companying regular droughts and floods. However, the poor marketing system is a primary reason for high shares of home-consumed production of crops - maize, vegetables, cashew, etc.

Traditional *coping mechanisms* of local communities to overcome the hardship of droughts and floods include game hunting, the sale of firewood and charcoal, sale of livestock, sale of local home-made beverages, casual agricultural wage employment on local farms, temporary labor migration to neighboring districts and regions. However, many of these alternatives have reached their limits as survival strategies. According to periodic FAO/WFP Crop and Food Supply assessments, the capacity of better-off farmers to absorb local casual labor has been reduced in many places by the exhausting cumulative effect of consecutive droughts and floods. Prices of maize and grains in deficit districts continue rising, compared with previous years and barter conditions have deteriorated. Malnutrition rates are high, and elevated mortality due to malaria, diarrhea and HIV/AIDS is increasing according to the official statistics.

The investigation into rural vulnerability to water factors undertaken as part of this study[21] indicates on an anecdotal basis that access to secure water sources to support livelihoods is considered of primary importance by rural households, to the extent that households and entire communities have migrated and resettled to gain access to such sources (eg. dams etc).

> **Reducing the vulnerability of the rural poor to water shocks through flood management and increasing water accessibility for productive use (eg through small dams, water harvesting etc.) will provide the greatest benefit to the largest number of people, even if the benefits are not discernable from a macro-economic perspective.**

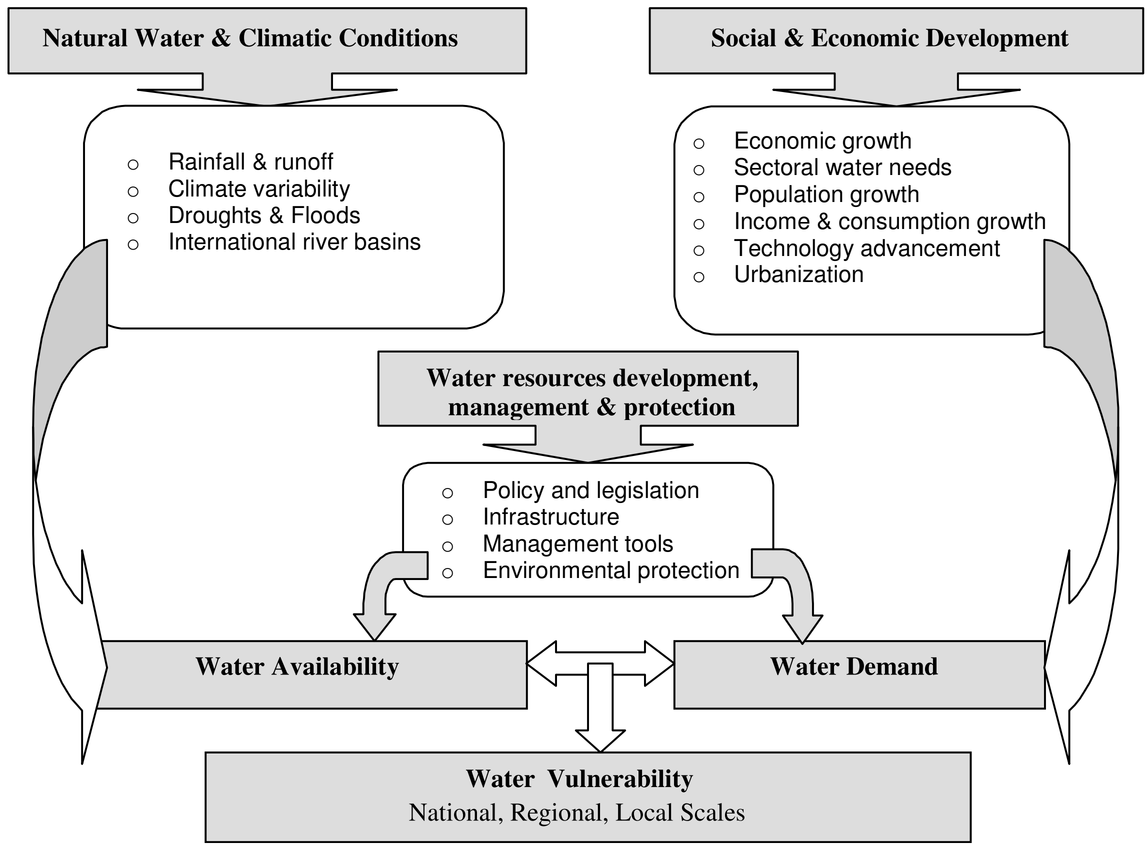
4.7 Water development, management and protection

As has been shown in this document, the two elements of water shocks and under-development of water resource infrastructure have a considerable impact throughout Mozambique's economy. The question is whether there is anything that can be done to reduce the impact and de-link the economy from climatic variability and ensure that there is sufficient water available to support economic growth and poverty reduction. Whilst it is not possible to provide complete protection against extreme events, it is certainly possible to reduce their impacts as is practiced throughout the developed world. The preliminary indicative economic analysis undertaken in Section 4.5.4 indicates that it would be economically feasible to reduce the vulnerability of the economy to water shocks and substantially reduce the water related constraints to growth through the development and management of water resources. However, the development of water related infrastructure adequate to provide for a growing economy and to protect against water shocks is costly. Attention should also be given to non-structural management options such as engaging with upstream riparian countries to encourage improved management of international waters to reduce the risk to Mozambique of extreme events. Such physical and non-physical developments require a high level of technical expertise and will involve lengthy planning, construction and commissioning periods. However the 'doing nothing' alternative would clearly be more costly.

Mozambique has certain innate water resource related conditions including those determined by its climate and geophysical realities and those determined by its political legacy – the large number of international rivers. These factors determine the water availability. Similarly there are a number of social and economic factors which determine the demand for water. These are illustrated in Figure 3.

[21] "*Local Vulnerability Study*" S. Gaye Thompson, September 2004

Figure 3 Addressing water vulnerability and constraint



Water availability and demand are not fixed, predetermined quantities – through the proper application of water resources development, management and protection activities it is possible to ensure that sufficient water is available to meet the demands and to protect the people and the economy from water shocks (droughts and floods). These three elements can be broadly described as follows (note that the elements overlap to some extent) –

Development entails a variety of activities which enable water to be controlled such as the construction of storage and flood control dams, diversion works, protection works such as dykes and levies, inter-basin water transfers, canals etc.

Management includes control of abstraction, licensing, administration of water rights, measuring and monitoring water flows, modeling and planning, ensuring efficiency of water use, water demand management etc

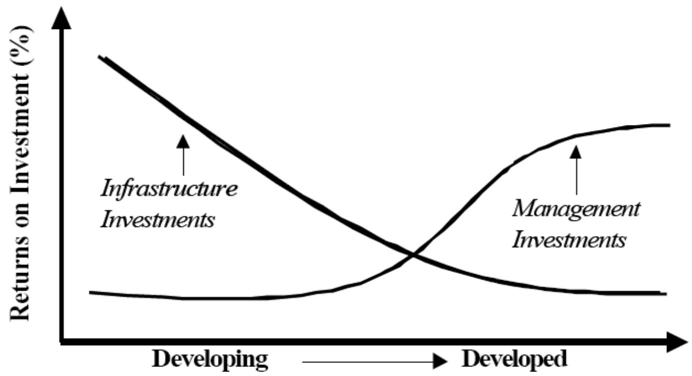
Protection ensures that the environment – the source of the resource – is protected to maintain aquatic fauna and flora, determining and ensuring in-stream flow requirements, water quality monitoring and water quality protection enforcement, protection of watersheds to reduce erosion and silt loads, etc

Mozambique is at a stage of economic development when infrastructure investments will generally have higher returns and will be more efficient in achieving water management objectives than focusing primarily on management improvements. World-wide experience demonstrates[22] that countries typically focus first on supply-side solutions in water resources management at earlier stages of their development, and then shift gradually to more demand and management-

[22] World Bank. China Water Resources Assistance Strategy, 2002

based approaches as the resources base gets closer to its full utilization. Figure 4 illustrates this statement.

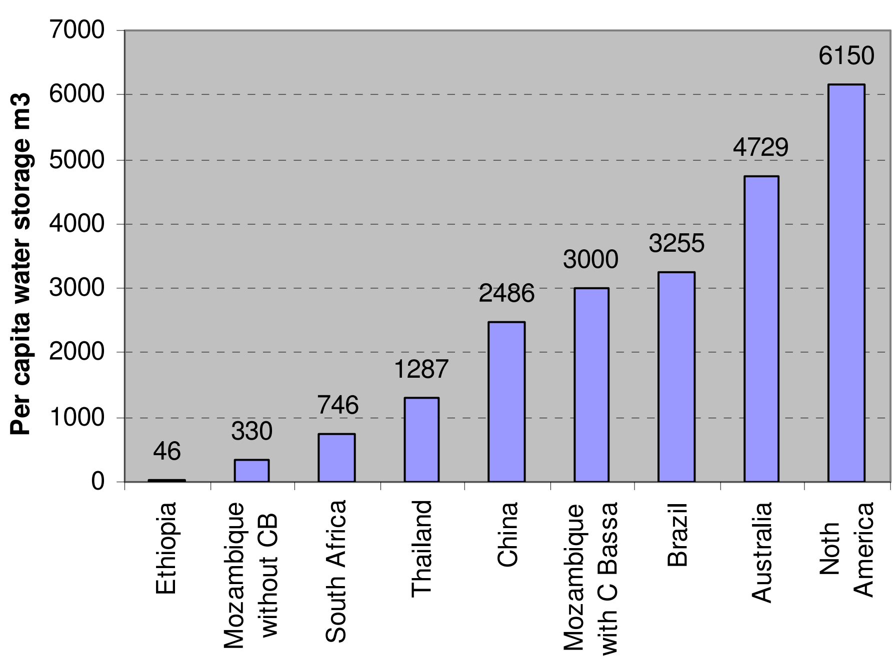
Figure 4. Rates of Return by Investment in Water Infrastructure



Source: World Bank. China Water Resources Assistance Strategy, 2002

The level of development of water infrastructure and, specifically, of storage capacity, is a useful indicator of the level of development of water resources available for direct economic use. As referred to in Section 4.3 - *Under-development of water* infrastructure, the storage capacity per capita in Mozambique is only 330 m^3 (excluding the Cahora Bassa Lake that accounts for more than 90% of the country's storage capacity), placing Mozambique among the Southern African countries with least developed water infrastructure. It is informative to compare this figure with the available water storage per capita in other countries as indicated in Figure 5 below. If the Cahora Bassa is excluded, the remaining 5800 Mm^3 of useful capacity represents only 5% of the mean annual runoff of the country's rivers, excluding the Zambezi.

Figure 5: Per capita build water storage - Africa's gap



The indication is, therefore, that the Mozambican Government should currently be emphasizing the development of water resources. Once a basic stock of water infrastructure has been developed, the emphasis will undoubtedly shift to management. In order to ensure viability and long term sustainability, such development should take into account all necessary considerations of the environmental and social impacts of water resources development.

5 Conclusions

The implications of this study are summarized in the Executive Summary in Section 1. Although the scope of the study has been limited it is clear that there are compelling arguments for further refinement. A clear identification is required of a strategy to address the vulnerability of the Mozambique economy to water shocks and the constraints to growth and poverty reduction imposed by an inadequate stock of water infrastructure. It is planned to follow this study with the preparation of a Country Water Resources Assistance Strategy (CWRAS) in close collaboration with the Government, the World Bank Country Team and other development partners. The CWRAS would include:-

1. Further analysis of future water demands by sector, including the water needs of 'mega-projects'.
2. An analysis of the water infrastructure investment needs to reduce poverty and support growth, building on this study;
3. The identification of priority investment requirements and opportunities;
4. An analysis of financing options (public and private); and
5. A consensus building process on the way ahead involving a wide range of stakeholders including non-water sectors, in-country role-players (both government and non-government), the World Bank Country Team etc.

It is reemphasized that:-

> **These matters are not "water problems" – they are grave issues facing the economy of Mozambique as a whole. They impact on the whole of the country and on the poor in particular. They are of a magnitude and of an all-encompassing nature that will impinge on and negatively effect the best efforts made in all other sectors. Investment in water resources infrastructure is the only way in which Mozambique can stop the continuous drain on the economy and the extensive human costs caused by recurrent floods and droughts, and the only way to provide reliable sources of water which any economy needs to grow in strength and diversity.**

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Appendix 1 – Provisional Analysis of Proposed Investments

A provisional economic analysis was carried out to provide an initial assessment of whether the proposed investments in the water resources sector are likely to be economically viable. [See Section 3.4 - *Government Water Infrastructure Development* Strategy]. **Note that it should not be inferred from the use of the draft investment strategy data (see Table 4) in this analysis that the proposals or data in the draft strategy are endorsed (or not endorsed) by the World Bank – the information is used for illustrative and comparative purposes only.**

The cost-benefit analysis was based on a comparison between a "do-nothing" and a "do something" option:

- the "do nothing" scenario assumed that no investments in the water sector were undertaken to mitigate the impacts of water shocks. The option had no costs and long-term GDP growth was assumed at 5% pa;
- the "do something" or "invest-in-water-resources" scenario had investment costs of US$1.063 billion as proposed by the consultant study (Table 4). This scenario assumed that the proposed investments would result in an increased GDP growth rate due to the avoided water shock-related losses in the country's economic growth (see Section 4.5.4). Specifically, it was assumed that this would lead to a 75% mitigation of the 1.1% annualized loss in the growth rate due to water shock events. This mitigation effect was included in the analysis as the only economic benefit of the proposed investments *and did not take account of the benefits of meeting growing water demands for development, that is, removing the constraints to the economy due to current under-development of water infrastructure*. The scenario also included assumptions on the investment implementation schedule that are summarized in Table 9 below:

Table 9. Assumed Investment Schedule

Investment component	Starting year of implementation	Implementation duration (years)	Costs (US$ million)
Flood Protection	1	10	270
Irrigation Rehabilitation & Small Irrigation	1	10	120
Hydropower development *	1	3	50
Dams and Transfer works:-			
Moamba Major dam and pipeline	1	5	265
Bue Maria Dam	1	5	150
Third large dam (possibly Mapai)	11	5	150
Medium size dams for irrigation	11	10	45
Others (basin planning, inventories, etc.)	1	1	13
TOTAL			1063

*Notes: * In addition to substantial Private Sector investments*

The analysis shows that the proposed government package of water sector investments is economically viable taking into account only the value of the mitigation benefit (and not the removal of constraints to development resulting from under-investment) and assuming a discount rate of 8%: the calculated Economic Internal Rate of Return (EIRR) was 10.1%, NPV – US$0.209 billion, and Benefit/Cost ratio (B/C) - 1.29. The annual investment required to implement the strategy is 80-90 US$ million, annual cost of not investing ('do-nothing' alternative) is approximately 120 US$ million due to water shocks alone, excluding growth foregone through under-investment in water infrastructure. A sensitivity analysis was carried out to assess sensitivity of the CBA results to variations in the discount rate and expected value of the project benefits.

The analysis demonstrated that the project is sensitive to the changes in the discount rate: with a discount rate of 10% the project becomes marginal with NPV of 0.005 and EIRR of 10.1. However, the project is also sensitive to the increase in the value of expected benefits: an increase in the benefits by 10% increases the EIRR by 0.8%-1.1%. Therefore, with a discount rate of 10% and the value of benefits increased by only 10%, the investments remain economically viable with EIRR of 10.9%, NPV of US$0.072 billion, and B/C ratio of 1.11. Given the fact that the value of benefits included in the analysis is sufficiently underestimated, the proposed investments are likely to be economically viable with a discount rate of 12 percent as well.