

Zambezi River Basin

Sustainable Agriculture Water Development

Angola, Botswana, Malawi, Mozambique,
Namibia, Tanzania, Zambia, Zimbabwe



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Abbreviations and Terms

| | |
|---------------|--|
| AAP | African Action Plan |
| ACP | Agricultural Commercialization Plan—Zambia |
| AfDB | African Development Bank |
| ARA | Regional Water Administration—Mozambique |
| ARDA | Agriculture and Rural Development Authority |
| AREX | Agricultural Research and Extension |
| ARWR | actual renewable water resources |
| BIPP | Bankable Investment Project Profile |
| BWO | Basin Water Office—Tanzania |
| CAADP | Comprehensive Africa Agriculture Development Programme |
| CAH | cereal area harvested |
| CEM | Country Economic Memorandum |
| CN | concept note |
| DANIDA | Danish International Development Agency |
| DNA | National Directorate of Water—Mozambique |
| DNHA | National Directorate of Hydraulic Agriculture |
| DOI | Department of Irrigation—Malawi |
| DSS | decision support system |
| EFR | environmental flow requirements |
| ERR | internal rate of return |
| ESW | economic and sector work |
| ET | evapo-transpiration |
| EU | European Union |
| FAO | Food and Agriculture Organization |
| FTLRP | Fast Track Land Reform Programme—Zimbabwe |
| GEF | Global Environment Facility |
| GIS | geographic information system |
| GoZ | Government of Zimbabwe |
| GDP | gross domestic product |
| GNP | gross national product |
| GPZ | Agency for Development Planning of the Zambezi Region (Mozambique) |

| | |
|-----------------------|---|
| GVA | gross value added |
| HEP | hydroelectric power plant |
| HP | horsepower |
| ICR | implementation completion report |
| IDF | Institutional Development Fund |
| IDF | Irrigation Development Fund—Zambia |
| IFAD | International Fund for Agricultural Development |
| IFST | Irrigator Facilitation and Support Team |
| IO | irrigator organization |
| IROP | Integrated Rural Development Program |
| IRWR | internally renewable water resources |
| IUCN | World Conservation Union |
| IWMI | International Water Management Institute |
| IWRM | integrated water resources management |
| JICA | Japanese International Cooperation Agency |
| LI | low investment |
| LSCF | large-scale commercial farms |
| MACO | Ministry of Agriculture and Cooperatives—Malawi |
| MADER | Ministry of Agriculture and Rural Development |
| MDGs | Millennium Development Goals |
| MERP | Millennium Economic Recovery Programme |
| Mha | million hectares |
| MI | medium investment |
| MIIF | Marketing Improvement and Innovation Facility |
| Mm³ | million cubic meters |
| MOAIFS | Ministry of Agriculture, Irrigation, and Food Security—Malawi |
| MOPH | Ministry of Public Works and Housing |
| MSAT | Multidisciplinary Scheme Assessment Team |
| Mt | metric ton |
| MW | megawatt |
| NAMPAD | National Master Plan for Agricultural Development (Botswana) |
| NEPAD | New Partnership for Africa's Development |
| NGO | nongovernmental organization |
| NIMP | National Irrigation Master Plan |
| NMTIP | National Medium Term Investment Programme |
| NPCC | national program coordinating committee |
| O&M | operation and maintenance |
| PFI | private financial institution |
| PPDT | Participatory Scheme Planning and Design Team |

| | |
|----------------|---|
| PRSP | Poverty Reduction Strategy Paper |
| PSPU | Program Support and Preparation Unit |
| RBMSSIP | River Basin Management and Small-Scale Irrigation Project |
| RBZ | Reserve Bank of Zimbabwe |
| ROR | run-of-river |
| RSA | Republic of South Africa |
| RSAP | Regional Strategic Action Plan |
| RWR | renewable water resources |
| S | storage |
| SADC | Southern African Development Community |
| SAPP | Southern Africa Power Pool |
| SH | Smallholder |
| SIAR | Scheme Improvement Assessment Report |
| SISP | Smallholder Irrigation Support Program (Zimbabwe) |
| SSIDS | Small-Scale Irrigation Development Study (Malawi) |
| SSR | self-sufficiency ratio |
| SWAP | sector-wide adjustment programs |
| TA | technical assistance |
| TRWR | transboundary renewable water resources |
| TSC | Technical Steering Committee |
| UNEP | United Nations Environment Program |
| WFP | World Food Program |
| WRM | water resources management |
| WRMS | Water Resources Management Strategy |
| WUA | water user association |
| ZACPLAN | Zambezi Action Plan |
| ZACPRO | Zambezi Action Plan Project |
| ZAMCOM | Zambezi Watercourse Commission |
| ZAPF | Zimbabwe Agriculture Policy Framework |
| ZINWA | Zimbabwe National Water Authority |
| ZRA | Zambezi River Authority |
| ZRB | Zambezi River Basin |

Currency Equivalents

| | |
|--------------------|-------------------|
| Angolan new kwanza | US\$1.00=Kz58.17 |
| Botswana pula | US\$1.00=BWP4.78 |
| Malawi kwacha | US\$1.00=MK119 |
| Mozambique metical | US\$1.00=Mt23,730 |
| Namibia dollar | US\$1.00=ND6.15 |
| Tanzania schilling | US\$1.00=Tsh1100 |
| Zimbabwe dollar | US\$1.00=Z\$6125. |
| Zambia kwacha | US\$1.00=ZK4635 |

Units

$$1 \text{ km}^3 = 1,000 \text{ Mm}^3$$

$$1 \text{ Gl} = 1,000 \text{ Ml} = 1 \text{ Mm}^3$$

$$1 \text{ m}^3/\text{s} = 31.54 \text{ Mm}^3$$

$$1 \text{ l/s/day} = 86.4 \text{ m}^3/\text{day} = 8.6 \text{ mm/ha/day}$$

| | |
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Executive Summary

The objective of this study has been to identify the potential and modalities for a major scaling up of economically sustainable and environmentally sound investment in water for agriculture and rural development in the Zambezi River Basin (ZRB). While the study focused strongly on scaling up irrigated agriculture, the analysis demonstrates why a broader and more *comprehensive water for agriculture strategy* that encompasses rainfed agriculture is cost-effective, growth and poverty oriented, and makes economic sense for the countries in the ZRB. The study shows that a major scaling up of irrigation is possible, but that the market drivers for such growth are limited. Much work will be necessary to foster farmer demand for and commitment to irrigation, and careful attention must be paid to the profitability of irrigation and the viability of investments. While the study did not have an explicit climate change focus, the issue of climate variability and its impact on potential basin yield is very much imbedded in the analysis regarding water availability.

The conclusion that a major scaling up of irrigated agriculture is needed and viable rests on two different perspectives on sustainability. The first concerns water availability and prospects for integrated water resource management in the ZRB. The second concerns the potential for realizing the positive economic impacts that this scaling up could have on agriculture sector growth and rural poverty.

Under a high growth scenario, an investment of between US\$1,280 and US\$1,650 million would be needed to finance an increase of about 367,000 hectares (ha) of irrigated agriculture in the ZRB over the next 15 years. At a low level of value added per hectare for smallholder irrigation of about US\$400/ha, this investment would yield an economic internal rate of return (ERR) of about 10–14 percent, at an average cost of US\$3,500 to US\$4,500 per hectare. Higher ERRs are very possible at higher average value added per hectare. This financing will be needed over the next 15 years at an average rate of about US\$110 million per year (higher if the absorptive capacity improves) spread among the eight ZRB countries in proportion to their potential, commitment, and capacity to scale up.

KEY FINDINGS

Importance of Managing the Zambezi River Basin

The water resources of the ZRB are crucial to each of the countries' aspirations for agriculture sector growth and poverty reduction (as well

as growth in other economically important sectors). Analysis based primarily on the Zambezi Action Plan Project (ZACPRO) 6.1.2 Sector Studies carried out for the ZRB in the late 1990s (chapter 2) shows that, in terms of average annual stream flow, there are ample water resources in the basin to support a major scaling up of water use for irrigated agriculture. If the current estimated rate at which the riparian countries could expand irrigated area were tripled, the irrigated area in the basin would increase from about 3.6 percent of the ZACPRO estimate of total cultivated area of 5.2 million hectares (Mha) to about 10.6 percent (551,000 ha) in 2020. Net water use under this scenario would rise from 2 percent to about 5.8 percent of the ZACPRO estimate of average water availability of about 95,000 million cubic meters (Mm³).

While these figures show that in the aggregate in an average year there is ample water available, several factors argue that for this level of water use in agriculture to be sustainable, water resources will have to be diligently *managed*.

- First, most of the streamflow in the ZRB occurs in the single wet season—perhaps 90 percent—and rainfall is often erratic, unreliable, and subject to frequent multiyear low rainfall cycles. The main stem of the river is controlled by the huge reservoirs at Kariba and Cahora Bassa, but the tributary rivers where the development potential is concentrated experience very low or no streamflow in the dry season even in average years when irrigation water demand is highest and other needs must also be met. For this reason, a focus on more efficient use by all users is most important as water demand grows.
- Second, the extensive riverine wetlands and flood plain areas in the basin have high economic and social value in terms of agriculture, fisheries, wildlife, and tourism as well as other environmental services, and these are already threatened by water pollution and uncontrolled and unmanaged water use, including storage for hydropower generation.
- Third, there are extensive hydropower resources that remain to be developed in the basin that consume substantial quantities of water. Current evaporation from reservoirs is about six times irrigation consumptive use and requires well-managed and regulated streamflows, pressuring upstream users to restrict withdrawals.
- Fourth, flood control, particularly in the Lower Zambezi valley, and prescribed flooding in the socially and economically important delta region, require cooperation with upstream riparians including adjustments to how reservoirs are operated and conservation of natural flood plain storage areas to mitigate damages.
- Fifth, the riparian countries of the basin have plans for the development and use of water resources for a wide range of economic and environmental purposes. Integrating these growing demands is an important management task so that each country is able to fully develop its equitable share of the resource without harming the development aspiration of its upstream and downstream neighbors.

Institutional Arrangements for Basin Water Management

Institutional arrangements for water resources management are being created and strengthened in each of the riparian countries, and increasingly irrigation development will be based on a basin approach and well coordinated with basin authorities. Equally if not more importantly, under the new Zambezi Watercourse Agreement, a new basin-level institution, the Zambezi Watercourse Commission (ZAMCOM), will be established. This new institution is needed to establish a framework within which the countries can jointly manage the water resources of the basin. ZAMCOM's role would include:

- Preparing rules for implementing the provisions of the agreement including a framework for joint water management at key locations in the basin (section 2.4) to ensure irrigation, hydropower, flood control, and environmental benefits upstream and downstream.
- Determining environmental flow requirements in the main river network.
- Preparing a basin development plan and strategy that integrates the development plans and aspirations of the member countries including irrigation.
- Supporting the strengthening of national integrated water resources management (IWRM) by growing the knowledge base,

developing a shared decision support system (DSS) and the expertise to use it, upgrading the monitoring network, and promoting the sharing of experience.

Importance of Irrigation in Agriculture Sector Growth and Poverty Reduction

Both land and water resources are ample at the basin level, although water is not always in the right place at the right time, and there are a number of important factors and problems that strongly influence the profitability of smallholder irrigated agriculture. A major scaling up of irrigated agriculture is possible based on new models and approaches emerging in the region:

- A high growth scenario, under which the current estimated rate at which the riparian countries could expand irrigated area is tripled, the irrigated area in the basin would rise to about 551,000 ha, and about 6 percent of the rural population in 2020 would have access to improved irrigated land and direct increases in income.
- Indirectly, an additional 6–12 percent of the rural population would benefit through employment (on- and off-farm), lower food prices, increased food availability, and the general rise in rural economic activity induced by the expansion of profitable irrigated agriculture. Hence, a total of about 12–18 percent of the rural population in 2020 would directly or indirectly benefit.
- About 80 percent of the rural population is not directly or indirectly reached by this investment in irrigated agriculture. If irrigation expansion takes place as a part of a *comprehensive water for agriculture strategy* to improve agriculture productivity, then a wider impact on rural poverty and food security could be achieved through the introduction of conservation farming and water harvesting supported by strong extension services and improved inputs.
- If smallholder farmers are to become, in effect, commercial farmers, then they must have the same secure water rights with known reliability that large-scale commercial farmers expect, since this is crucial to effective production planning and increased productivity.
- The active participation of smallholder farmer groups in basin management (catchment and basin councils, for example) will tend to enhance the role of irrigation in basin water administration, planning, and decision-making, especially in regard to such issues as water allocation, expansion of water use, watershed management, conservation strategies, and infrastructure development plans.
- The concrete and very favorable experience with this approach in Tanzania, for example, showed that when farmers participate in basin administration and management activities, they develop a stake in the wider issues of water conservation and management, and a greater sense of shared purpose—creating a win-win situation when improved water management and more efficient use of water is an important focus of smallholder irrigation improvement programs.

Learning from Existing Models

The study has not undertaken an extensive expost assessment of project and program experience on the ground, although this should soon be done before the scaling-up program moves too far along. However, based on discussions with sector officials, donors, and the review of documents, including selected project implementation completion reports, the following lessons should be kept in the forefront:

- Programs should address the issues that undermine smallholder profitability at each step of the value chain, and to do this the existing and potential private sector actors must be brought into the program by providing incentives, such as favorable policy reforms and access to financing.
- Program financing mechanisms should be structured to impose high appraisal standards and commercial discipline on sub-project sponsors to ensure that the programs

Importance of a Basin Approach to Irrigation Development

Irrigation development would benefit from a basin approach for several important reasons:

- remain demand driven, and do not creep steadily toward traditional bureaucratic, government, supply-driven approaches.
- Cost minimization and cost-effectiveness are paramount in ensuring that subprojects are financially and economically sound.
 - Governments' desires are high and their capacities to administer and manage a scaled-up water for agriculture program are extremely limited. Hence, it will be essential for governments to outsource the essential technical and social services needed to implement accelerated programs.
 - Governments' capacities to coordinate, manage, and supervise the programs must be strengthened. Decentralization remains crucial for the sector in order to locate the most important strategic expertise—such as, irrigation and rainfed agriculture advisory services strongly linked to a revitalized research system—as close as possible to the rapidly expanding number of new smallholder farmer groups.
 - Continuing training of farmers and farmer groups in topics ranging from how to lead, manage, and operate their new organizations to water management and new crops and cropping practices, has been well demonstrated to be crucial for long-term success.
 - Programs must be targeted to maximize the opportunity for early success and demonstration. This will depend in large part on upgrading monitoring networks and information systems and improved planning. The current deteriorated state of the hydrologic monitoring networks and the lack of planning have resulted in very limited and poorly documented investment portfolios, further limiting the ability to attract investment financing.

Partners and Partnerships

Except for very small farmer or community groups or the poorest farmers, donors have given less importance to irrigation for some time, in part because their experiences with achieving success commensurate with the costs has been uneven at best. Nevertheless, because of the pervasive poverty in the region, donors—including The International Fund for Agricultural Development (IFAD), the European Union (EU) and the Japanese International Cooperation Agency (JICA), and the

African Development Bank (AfDB)—have continued to invest in the rural sector including improving livelihoods, infrastructure, and small-scale irrigation. This is beginning to pay off in the sense that the body of knowledge is growing on the ways to successfully promote improved agriculture and livelihoods among the region's poor. For example, the success of IFAD in working with farmer and community groups in its flood plain agricultural project in Malawi has become one of the key building blocks for the new World Bank agriculture development project in Malawi. As the World Bank, in partnership with other donors, begins to formulate approaches to scaling up investment in water for agriculture they should work toward a harmonized approach to improving irrigated and rainfed farming to reach a critical mass of financing.

RECOMMENDATIONS

New Investment Interventions

As chapter 6 suggests, new investment interventions should utilize flexible and adaptable programmatic approaches that seek to institutionalize a model for scaling up investment in water for agriculture and for integrated water resources management, initially building on and filling the gaps in current programs.

Such an investment approach could include: budget support, sectorwide adjustment programs (SWAPs), or programmatic sector investment loans. However, because of weak institutions and the inability to target and track expenditures through the budget, budget support operations may not be appropriate in the early years. A SWAP would create opportunity for a group of donors to blend together their experience and jointly support a model approach in a country or major sub-basin of the Zambezi, and enhance the potential for scaling-up and targeting of investments. A programmatic sector investment operation has the advantage of focusing strongly on the model for small-scale irrigation improvement within a wide framework of potential investments: formal irrigation; watershed management and water harvesting; conservation farming; very small or microirrigation schemes; as well as major public infrastructure where it is needed. It can also focus on: the institutional arrangements and operations of new and innovative funding mechanisms that include incentives for greater private sector initia-

tives to enhance and secure the smallholder value chain; outsourcing technical services; and institutional strengthening and capacity building. This latter type of operation offers ample opportunity for cofinancing by several different donors, who have distinct interests and comparative advantages. It also has the flexibility to structure the operation in a way that complements other World Bank and donor programs and projects in a way that captures synergies.

Absorption and institutional capacity is deficient. Hence, the learning curve will be long with any program and model. One way to scale up and increase capacity in a more focused and targeted way is to support the use of private sector providers. In this case, the government trains to become a coordinator, facilitator, monitor, and supervisor of private sector providers using performance-based contracts.

The study identified several new initiatives that complement ongoing, completed, or new World Bank investment options, including:

- Mozambique—Support for the lower Zambezi Valley smallholder irrigation and rural development program (GPZ) (possibly modeled on the RBMSSIP project in Tanzania)
- Namibia—Implementation of the Green Scheme Phase I
- Tanzania—Nyasa Basin RBMSSIP program
- Zambia—New smallholder irrigation improvement project

Regional Programs

Regional programs, possibly supported through the Global Environment Facility (GEF), the Institutional Development Fund (IDF), other trust funds, or by individual or groups of donors, may be of particular value and could support:

- Establishment and functioning of ZAMCOM.
- Structuring new partnerships among the Zambezi countries in such important areas as the use of strategic environmental assessments.
- Determining environmental flow requirements and developing strategies, to satisfy these requirements.
- Identification and planning of new multi-country infrastructure.
- Developing, installing, and operating a modern, low-cost regional water quantity and quality monitoring network that would

upgrade regional and national hydrologic information systems and planning.

- Developing DSSs that the Zambezi countries can use separately and jointly to study strategic water development and management options.
- Upgrading and updating the ZACPRO sector studies and water resource assessments.

These are just a few examples of the collaborative work that would have a high priority in the near term.

Analytical and Advisory Services

Analytical and advisory services would be extremely useful for assessing and prioritizing options for implementing the various agriculture sector studies and plans and irrigation sector policies and strategies that have been prepared by Zambezi countries and donor partners, but have not been translated into programs that could be readily supported. The study findings suggest several priority areas:

- Angola—Preparation of irrigation sector policy and strategy and implementation options.
- Botswana—Evaluation of Phase I of the National Master Plan for Agricultural Development (NAMPAD) Zambezi Irrigation Development Project.
- Malawi—Development and evaluation of options for IWRM, basin management, and irrigated agriculture development in the Shire River Valley.
- Mozambique—Evaluation of integrated development and program options for the Lower Zambezi Valley.
- Zimbabwe—Assessment of options to implement recommendations of the World Bank Agriculture Growth Study (pillar 2) and the Bank of Zimbabwe Drought Mitigation and Resuscitation.
- Zambia—Update of the Irrigation Master Plan.

Immediate Business Needs

The final riparian stakeholder workshop recommended that a strategy and approach to program formulation will be different from country to country because of differing states of readiness, and because of differences in opportunity, physical circumstances, past development, and capacity. Nevertheless, the principles in the study findings outlined above provide a common and agreed base

from which to work. From this perspective, the countries agreed on two basic critical needs:

- *A regional strategic plan for the development of irrigated agriculture*—This plan is intended to be a critical input into the Zambezi multi-sector strategic plan called for in the agreement* and presently under preparation by ZAMCOM and Southern African Development Community (SADC). This regional strategic plan is seen as the essential regional framework within which national investment programs to strengthen IWRM and scale up irrigated agriculture can be prioritized and sequenced and concrete programs formulated.
- *An irrigated agriculture Program Support and Preparation Unit (PSPU)*—Business as usual on the part of donors and governments in the region was seen as an unlikely way to move forward in a timely manner. The countries agreed with the concept of establishing a unit dedicated to supporting and assisting with the preparation of plans and programs in each of the ZRB countries. What is needed is a concentration of resources, effort, and expertise to overcome bottlenecks, assist with the completion of essential preparation activities, and assist with the formulation and design of so called bankable programs.

* The agreement to establish the Zambezi Watercourse Commission (ZAMCOM) was signed on July 13, 2004 in Kasane, Botswana between the eight Zambezi river basin riparian states. Seven of the eight countries signed the agreement while, the eighth country, Zambia is yet to sign as the country is still consulting its stakeholders.

1.1 BACKGROUND

This study focuses on how the eight countries that share the Zambezi River Basin (ZRB) in southern Africa can jointly and separately develop and manage the water resources of this river basin to expand and intensify irrigated agriculture, reduce rural poverty, and improve food security.

Agriculture has an important role in the economy of these countries and is central to the livelihood of the rural poor. Throughout most of the ZRB, utilization of agricultural land and water resources is very low. Less than 4 percent of cultivated land in the basin is irrigated. Rainfed farming is subject to high hydrologic risk and crop yields are very low. On average, about 70 percent of the basin population depends in one way or another on agriculture. Poverty is very high, especially in rural areas, and ranges from 60–80 percent.

Traditional smallholder farmers, who constitute up to 80 percent or more of the farming community, grow mainly a single staple food grain and maintain small horticulture plots that rely on rainfall, except near wetlands and in flood plains. Informal irrigation using manual methods, and more recently manually operated pumps, in flood plains and wetlands is larger in scope than formal irrigation in many areas and is likely to continue to grow. Traditional irrigation using temporary diversion structure and small canals has been practiced in the limited areas where perennial streams are found. The majority of rivers flow only in the rainy season, putting a second crop beyond the reach of the great majority of farmers. The spread of rainfed farming onto marginal lands, fuelwood harvesting, and heavy production of charcoal have led to severe deforestation and soil degradation with silt and erosion, clogging the streams, reservoirs, and rivers. Few traditional farmers use fertilizers and pesticides, and access to improved seeds is generally limited.

Nevertheless, where farmers have access to reliable water supplies, and modern inputs are available and affordable, farmers have shown a willingness to intensify farming by shifting to cash inputs and higher value crops where market access is favorable. While there are numerous examples of farmers diverting and even storing water for irrigation using traditional methods, the lack of diversion, storage, and conveyance infrastructure that enables good water management constrains expansion of irrigation at rates that would reach a high proportion of the farming community and lead to the levels of agriculture growth needed for a major reduction in poverty and

improved food security. It is in this context of increased use of water resources for agriculture that the issue of joint management of ZRB waters has become a priority for the Zambezi riparian countries.

Despite serious problems with agriculture service provision and the inevitable implementation problems that will stem from a new irrigation sector policy framework and development approach, the basin countries see expansion of irrigation and improved access to water resources for smallholders as one of their key engines of rural sector growth and poverty reduction.

1.2 SADC AND THE ZAMBEZI PROCESS

The importance of improved water resources management and increased water utilization in fostering economic growth, alleviating poverty, and reducing food insecurity has long been recognized among the nations of the Southern African Development Community (SADC). In the mid-1980s, the United Nations Environment Program (UNEP) played a catalytic role in bringing the Zambezi riparian countries together to launch an action plan for the integrated development of the water resources of the ZRB.¹ The plan, called ZACPLAN, consisted of 19 projects called ZACPRO.

Within the ZACPLAN framework, SADC led and facilitated a process within the southern African community to translate the core principals as set out in UN Agenda 21 into a framework for water resource development within the region. The result of this process was the adoption of the Protocol on Shared Watercourse Systems by the member states in 1995.²

The complexity of the problems and great scope for water resources development in the ZRB made it a natural focus of SADC efforts to implement the protocol through a new regional watercourse institution for the ZRB, specifically a watercourse commission referred to as ZAMCOM. This process of collaboration among the Zambezi riparian countries, which really began in the late 1980s with support and facilitation from SADC, is known as the Zambezi Process.

The process culminated in the signing of a ZAMCOM agreement by seven of the eight Zambezi countries in July 2004 (Zambia is still considering the agreement). The countries' intention is for ZAMCOM to promote the equitable and rea-

sonable utilization of the water resources of the ZRB, as well as the efficient management and sustainable development of these resources.

1.3 OBJECTIVES OF THIS STUDY

The aim of this study is to identify the potential and modalities for a major scaling up of economically sustainable and environmentally sound investment in water for agriculture and rural development in the Zambezi basin countries. Expansion of irrigated agriculture is a priority in each of the basin countries to stimulate agriculture sector growth, promote growth in the rural sector, alleviate rural poverty, and improve household and national food security. This has been a goal of the Zambezi countries for some time, but progress has been slow and the current extent of irrigation in the Zambezi basin and in each of the basin countries is extremely low at a time when poverty is extremely high and food security is vulnerable. However, a major expansion of irrigation water use, alongside the growth in water use in other sectors, as well as the ecological requirements of the basin's ecosystems, if not evaluated from a holistic sub-basin and basin perspective could result in diminished and unsustainable benefits, conflicts, and negative impacts on other riparians.

A strategy that might help irrigated agriculture to "take off" would have to address two different types of perspectives and issues. On the one hand, it must address the national and local institutional, policy, economic, and social issues that have constrained irrigation development, as well as identify the modalities by which this "take off" could be facilitated and supported. On the other hand, it would have to address the regional and river basin issues associated with water allocation, protection of the resource, and conflict resolution. In addition, the interdependence among countries seeking cost-efficient solutions to problems such as hydropower capacity expansion; flood risk management; withdrawal of surface or groundwater for agriculture, drinking, and industrial needs' and management of environmental flows, suggests that cooperative and joint management activities and investments in a river basin framework may also be necessary.

Irrigation development, or hydropower development for that matter, is commonly thought of as national or even local problem, but in the context of a river basin, the regional dimensions of these

and similar developments are important for several reasons. The most favorable lands with the highest productive potentials where investment in irrigated agriculture is likely to have high poverty and economic impacts are largely found within those areas of each country that constitute the principal tributaries of the Zambezi River—and not on the main stem of the Zambezi itself. Hence, in formulating a strategy for scaling up investments to expand irrigated agriculture in these areas and consequently increasing the extraction of surface water and groundwater, it is essential to define the broader basin context for this expanded use of water for agriculture in each country, and to identify the joint management challenges they represent for each country and for ZAMCOM. Two features, among many, of this basin context that are important factors to consider in formulating these country strategies are: first, the patterns of existing and future water supply and demand in the basin under different development scenarios; and second, the institutional, legal, and policy framework for the sustainable management of these basin resources that would ensure that each country's irrigation sector strategy is sustainable from this basin perspective.

1.4 APPROACH

This study and report are based on: (i) a series of brief missions to the ZRB countries, including Botswana, Malawi, Mozambique, Namibia, Tanzania, Zambia, and Zimbabwe³ in November 2004, May and June 2005, and November and early December 2005, to discuss irrigation and agriculture sector issues, policy frameworks, strategies, and plans as well as ZRB issues, and to collect data and reports; (ii) discussions with SADC's Water Division in Gaborone, the International Water Management Institute (IWMI) in Pretoria; the Zambezi River Authority (ZRA) in Lusaka; and the *Gabinete Do Plano De Desenvolvimento Da Regiao Do Zambezi* (Agency for Development Planning of the Zambezi Region—Mozambique [GPZ]) in Tete; (iii) discussions with donor and NGO representatives; and (iv) various documents and study

reports including those of the World Bank and other donors. These and other studies and reports consulted in preparing this study and report are given in the list of references at the end of this report.

It is important to note that this report is also based in part on the sector study reports prepared on behalf of the SADC and ZRA in 1998 under ZACPRO 6.1.2. (hereinafter referred to as ZACPRO 6). While much of the data and analyses in these reports are nearly 10 years old, they remain the most comprehensive and integrated body of data and analyses available for the ZRB. Since ZACPRO 6 was completed, there do not appear to have been major changes in the basin that would alter the broad outline of the study analyses and findings.⁴ In addition, data from the Food and Agriculture Organization (FAO's) AQUASTAT and FAOSTAT (2005), World Bank World Development Indicators (WDI 2005), and the World Resources Institute Earthtrends (WRI 2005), as well as data compiled from World Bank Country Economic Memorandums (CEMs), and other studies and reports were used. Also consulted were the important reports on the Zambezi delta and the ZRB prepared under the research program of the International Crane Foundation.⁵

1.5 OUTLINE OF THE REPORT

Chapter 2 of this report discusses the ZRB as the context for a major expansion in the development and use of the water resources of the basin, including current development, current and projected water use, environmental issues, integrated water management, and future joint water management challenges. Chapter 3 discusses the need for scaling up investment in irrigated agriculture in the basin, examines several scenarios, and the potential impact on poverty. Chapter 4 discusses the viability of investment in irrigated agriculture in the basin including demand and the factors that most significantly influence costs. Chapter 5 discusses demand, policy, and institutional issues. Chapter 6 outlines the findings of the study and the way forward, as discussed with the riparian countries in a workshop on March 1–2, 2006.

2.1 BASIN PERSPECTIVE

An outline of the ZRB, along with the main river and principal tributaries, the boundaries of the basin countries, and the boundaries of the 13 principal sub-basins,⁶ is shown in figure 2-1.⁷ The Zambezi sweeps nearly 3,000 km across southern Africa, encompassing an area of about 1.36 million km², including over 31 million people in the eight basin countries.

2.1.1 Distribution of Population and Development

The distribution of basin area among the eight basin countries is summarized in table 2-1, which also includes an estimate of the proportion of each country's population that lives in the basin. Zambia, Zimbabwe, and Malawi have a very high proportion of their land area (64–93 percent) and population (70–86 percent) in the basin. About 18 percent of the area of Mozambique, and about 19 percent of its population, are located in the lower Zambezi basin. The areas and populations of the other four basin countries within the ZRB—including Angola, Namibia, Botswana, and Tanzania—are comparatively small.

Between 65 percent and 75 percent of the total basin population is rural, and the density over much of the basin is very low (figure 2-2). Higher concentrations of people are found only around the major cities in the middle and lower basins, in limited areas of the Kafue, Kariba, and Luangwa sub-basins, and in large areas of the Shire–L. Malawi, and lower Zambezi River sub-basins.

2.1.2 Present Utilization of Water Resources

The renewable water resource endowment of each of the Zambezi countries and the current utilization of those resources are shown in figures 2-3 and 2-4.⁸ Actual renewable water resources (RWR) include both internal and transboundary renewable water resources (TRWR). The use of both internal and actual water resources per person is shown in figure 2-5, based on figure 2-4 and table 2-1. With the exception of Botswana (44 percent), agriculture utilizes about 70 percent to 90 percent of total water withdrawals in all the other Zambezi countries (figure 2-4).

Transboundary flows are a high proportion of actual RWR only in Botswana (80 percent), Mozambique (54 percent), and Namibia (65 percent) (figure 2-5). Actual RWR per person (figure 2-5) is generally high, exceeding about 2,400 m³/year, except in Malawi (1,401

Figure 2-1 Zambezi River Basin



m³/year), and in Zimbabwe (1,547 m³/year). In terms of internal RWR, Botswana, Malawi, and Zimbabwe (948 m³/year) are all below 1,500 m³/year. Current (2000) withdrawal of water per capita averages only 128 m³/yr or about 352 l/person/day, with Angola the lowest at 21 m³/yr and Malawi at 87 m³/yr. While, in general, use of water is low in the Zambezi countries, total withdrawal in Zimbabwe is already 34 percent of its internally available RWR.

2.1.3 The Status of Agriculture in the Zambezi Basin

Agriculture is an important component of gross domestic product (GDP) in most of the Zambezi countries⁹ as shown in figure 2-6. Apart from Angola, Botswana (principally livestock) and Namibia, where agriculture is less than 10 percent of GDP, the agriculture component of GDP in the other Zambezi countries ranges from 23 percent to 45 percent. In Malawi,

Table 2-1 Area and Population of the Zambezi Basin

| Country | Total area (sq km) | Area in basin (sq km) | % | Total population 1998 | Population in basin | % |
|------------|--------------------|-----------------------|------|-----------------------|---------------------|------|
| Angola | 1,246,700 | 145,000 | 11.6 | 13,168,000 | 487,200 | 3.7 |
| Namibia | 824,269 | 24,000 | 2.9 | 1,645,700 | 60,890 | 3.7 |
| Botswana | 582,730 | 84,000 | 14.4 | 1,500,000 | 12,000 | 0.8 |
| Zambia | 752,614 | 540,000 | 71.7 | 10,037,400 | 7,046,250 | 70.2 |
| Zimbabwe | 390,759 | 251,410 | 64.3 | 12,552,000 | 9,050,000 | 72.1 |
| Malawi | 118,484 | 110,390 | 93.2 | 11,407,000 | 9,821,400 | 86.1 |
| Tanzania | 945,087 | 27,000 | 2.9 | 31,798,000 | 1,271,920 | 4.0 |
| Mozambique | 799,380 | 140,000 | 17.5 | 20,791,000 | 3,991,870 | 19.2 |
| Total | 5,659,293 | 1,321,800 | 23.4 | 102,899,100 | 31,741,530 | 30.8 |

Source: Mohamedahmed (2004).

Note: Estimated basin total population was 38.4 in 1999.

Figure 2-2 Population Density

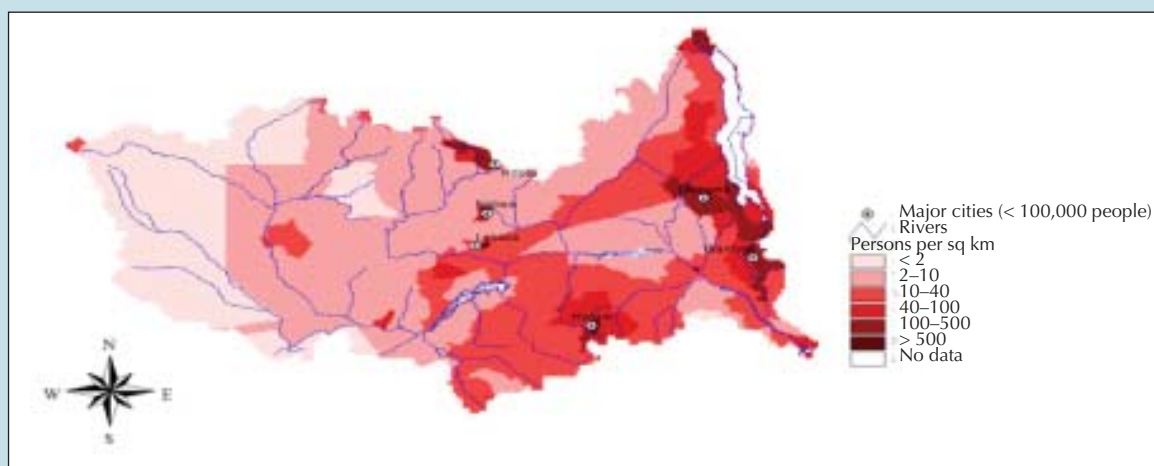
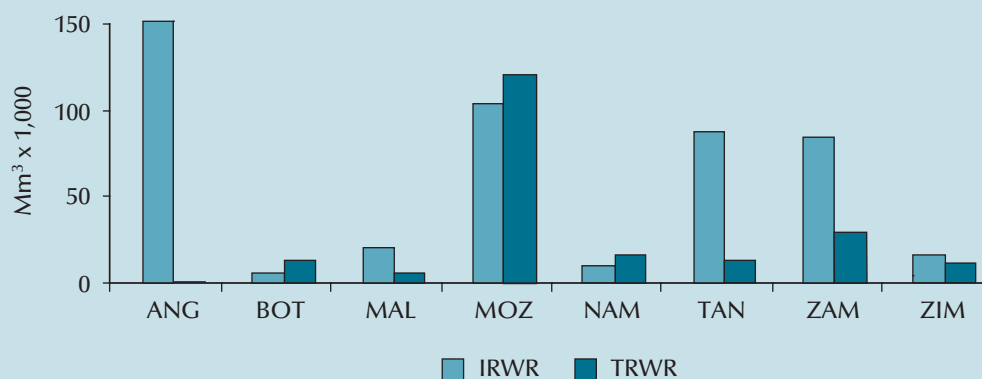
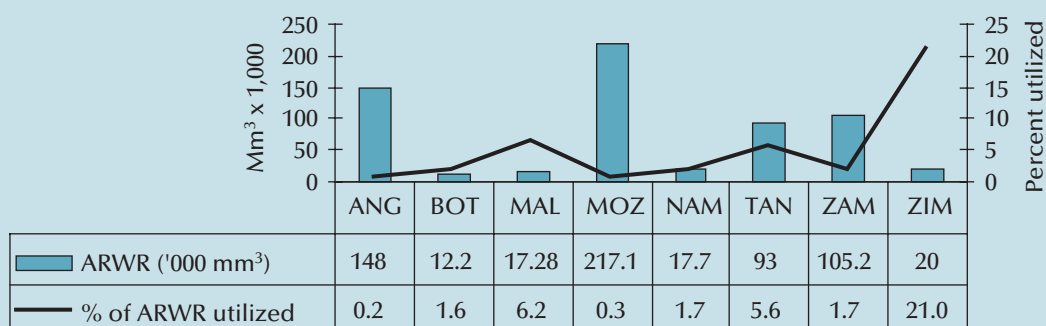


Figure 2-3 Internal and Transboundary Renewable Water Resources



Note: ANG = Angola, BOT = Botswana, MAL = Malawi, MOZ = Mozambique, NAM = Namibia, TAN = Tanzania, ZAM = Zambia, ZIM = Zimbabwe.

Figure 2-4 Utilization of Actual RWR (ARWR, Internal and Transboundary)



Note: ANG = Angola, BOT = Botswana, MAL = Malawi, MOZ = Mozambique, NAM = Namibia, TAN = Tanzania, ZAM = Zambia, ZIM = Zimbabwe.

Figure 2-5 Internal and Actual RWR per Person



Note: ANG = Angola, BOT = Botswana, MAL = Malawi, MOZ = Mozambique, NAM = Namibia, TAN = Tanzania, ZAM = Zambia, ZIM = Zimbabwe.

agriculture sector growth accounts for about 50 percent of the total GDP growth rate. In Mozambique, while agriculture is just 26 percent of GDP, it accounts for about 20 percent of the GDP growth rate.

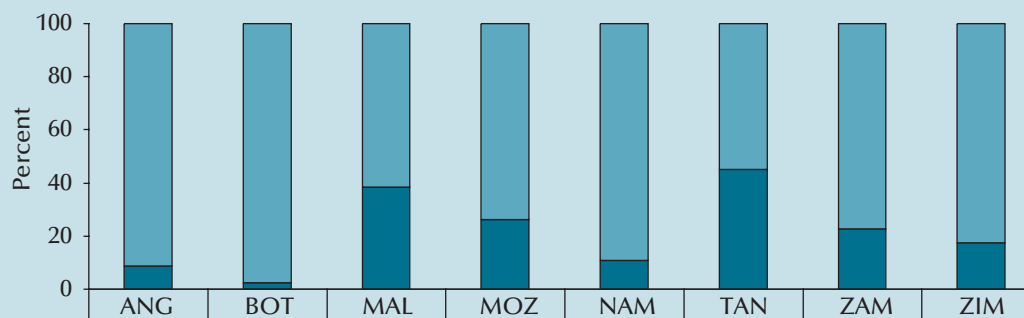
The distribution of cultivated areas (rainfed and irrigated) within the ZRB is shown in figure 2-7.¹⁰ Most of the cultivated land is located in just three of the riparian countries: Malawi, Zambia, and Zimbabwe (86 percent of the total of about 5.2 Mha). These same three countries had nearly 96 percent of irrigated areas. The proportion of water resources presently used by the key sectors (domestic, industry, and agriculture) in each of the basin countries is summarized in figure 2-8.

2.1.4 Hydropower Development in the Basin

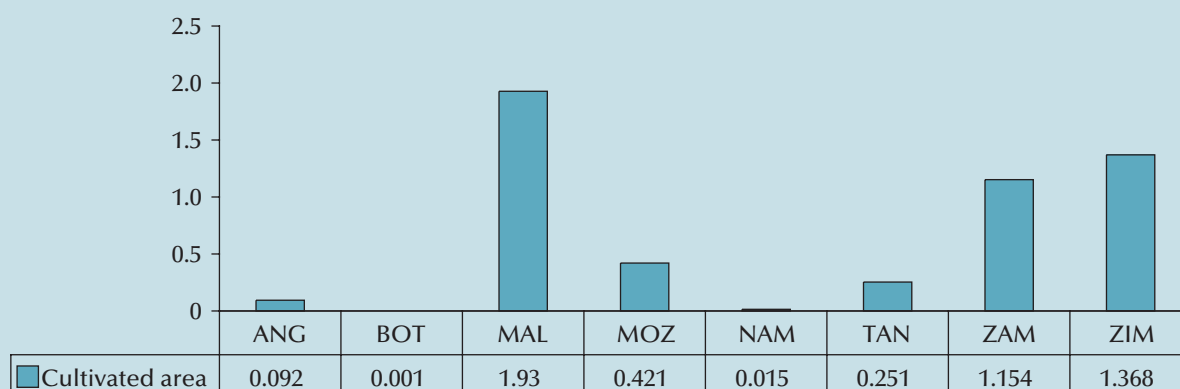
Eleven hydropower plants have been developed and operate in the ZRB as summarized in table 2-2.

The total installed capacity is about 4,684 megawatts (MW) and average annual energy generation is about 33,000 gigawatt hours (GWh). Total live storage in these reservoirs is about 127,000 Mm³, larger than the present mean annual outflow of the basin. About 75 percent of this capacity is installed at Kariba and Cahora Bassa on the main stem of the Zambezi River. These reservoirs constitute about 95 percent of total storage capacity in the basin. Kariba is owned jointly by Zambia and Zimbabwe and operated by the Zambezi River Authority (ZRA). Cahora Bassa is 82 percent owned by private Portuguese investors and nearly all the energy generated is exported under long-term contracts. The remaining plants are owned and operated by the respective utilities. About 20 new hydropower plants with a total installed capacity of 13,300 MW—some with large storage

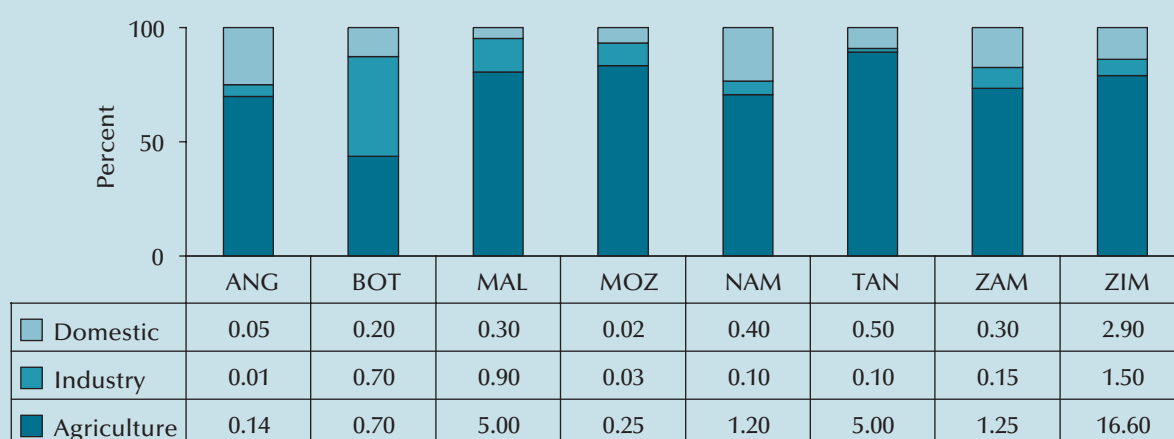
Figure 2-6 GDP and Agriculture Value Added (2003)



Note: ANG = Angola, BOT = Botswana, MAL = Malawi, MOZ = Mozambique, NAM = Namibia, TAN = Tanzania, ZAM = Zambia, ZIM = Zimbabwe.

Figure 2-7 Cultivated Area within ZRB (Mha)

Note: ANG = Angola, BOT = Botswana, MAL = Malawi, MOZ = Mozambique, NAM = Namibia, TAN = Tanzania, ZAM = Zambia, ZIM = Zimbabwe.

Figure 2-8 Utilization of ARWR by Sector (%)

Note: ANG = Angola, BOT = Botswana, MAL = Malawi, MOZ = Mozambique, NAM = Namibia, TAN = Tanzania, ZAM = Zambia, ZIM = Zimbabwe.

Table 2-2 Existing Hydropower Development in the ZRB

| Sub-basin | Power plants | Installed capacity (MW) | Average annual generation (GWh) |
|-----------------|---|-------------------------|---------------------------------|
| Kafue | Kafue Gorge (storage) | 900 | 5,900 |
| Kariba | Victoria Falls (ROR) ^a and North and South (storage) | 1,374 | 8,702 |
| Luangwa | Three small plants (storage) | 50 | 298 |
| Shire/L. Malawi | Five plants on the Shire R. (ROR) and one plant on Wovwe R. (ROR) | 285 | 1,093 |
| Tete | Cahora Bassa (storage) | 2,075 | 17,000 |

Source: Nira Consultancy 2003.

a. ROR = run of the river.

capacity—have been proposed to be constructed over the next 20 years.¹¹ Of these, about 8,500 MW have been proposed for the main stem of the Zambezi River alone. In the mid-term, it appears that two projects on the Kafue River—Itezhi-Tezhi (80 MW) and Lower Kafue Gorge (600 MW)—and two projects on the main stem of the Zambezi River—Batoka Gorge (1,600 MW) and Mapunda Unca (2,000 MW)—are both attractive and quite likely to be implemented.

2.1.5 Average Annual Water Availability for Development

ZACPRO 6's estimate of the annual availability of water resources is about 95–100 km³ (table 2-3),¹² or about 7–8 percent of average total rainfall. This volume is equivalent to the average outflow of the Zambezi River to the Indian Ocean. The difference between total average rainfall and the average outflow to the sea is accounted for by all forms of current consumptive use (crops, industry, domestic uses, and so forth) and evaporation and transpiration losses from reservoirs, wetlands, swamps, lakes, soils, and vegetative land cover including grasslands and forests.

ZACPRO 6 considered the estimate of evapotranspiration (ET) from wetlands and swamps (about 3 km³/year) to be a natural loss and included it as a part of actual ET. Similarly, ZACPRO 6 included the ET from rainfed agriculture on about 5,000,000 ha to be a part of the natural or actual ET. Hence, neither of these components of consumptive water use were included in table 2-3 as separate items. ZACPRO 6 estimated that there were 171,500 ha of irrigated land in 1995, or about 3.2 percent of the estimated total cultivated area in the ZRB in 1995 (5,200,000 ha).

2.2 CURRENT AND PROJECTED WATER USE

2.2.1 Agriculture, Domestic, and Industrial Water Use

Despite the limited data available, ZACPRO 6 carried out a systematic analysis of land use in the mid-1990s, and projected likely future changes in land use, particularly growth in irrigated agriculture. These studies estimated that irrigated area would grow from 171,551 ha in 1995 (about 3.6 percent of cultivated area) to about 259,700 ha in 2015 (about 5.4 percent of cultivated area). Water use for irrigation¹³ would grow from 1,448 Mm³/yr to 2,191 Mm³/yr as compared with total water availability of 95,000–100,000 Mm³/yr. Other bases and scenarios for estimating potential future irrigated areas in the basin and projected water use are discussed in chapter 3.

2.2.2 Consumption of Water in Hydropower Reservoirs

The major water user in the ZRB is hydropower in the form of open water evaporation from the reservoirs built for this purpose. ZACPRO 6 estimated the open water evaporation from the major reservoirs in the middle and lower basins to be nearly 17,000 Mm³/yr in 1995. The storage reservoirs associated with proposed new hydropower capacity would add another 19,600 Mm³/yr of water use in the form of evaporation. However, 90 percent of this increase would be at three sites—Chemba, Katombora, and Mupata—none of which were included among the list of the most attractive sites at that time. Proposed expansion of installed capacity at Victoria Falls, Kariba, and Cahora Bassa would not involve increased reservoir capacity and

Table 2-3 ZACPRO 6 Estimate of Water Available for Future Development in the Zambezi River Basin

| | Volume (km ³ /yr) |
|--|------------------------------|
| Total volume of water available in the Zambezi River Basin (excluding net losses from existing uses) | 110–115 |
| Net evaporation from hydropower reservoirs | 15 |
| Net evapo-transpiration from irrigation and consumption by livestock | 1.5 |
| Consumption by humans including industry | 1 |
| Average actual discharge to the Indian Ocean | 95–100 |

Source: Niras Consultancy 2003, ZACPRO 6 Sector Study Reports 1998.

water use. Water use associated with the remaining planned hydropower plants—4,200 Mm³/yr—is comparable to the water requirement for some of the irrigation expansion scenarios (chapter 3).

2.2.3 The Essential Role of Storage for Zambezi Basin Development

Growth of irrigated agriculture beyond the very modest increase forecast by ZACPRO 6 of about 90,000 ha would in all likelihood require substantial development of storage. Even for this modest increase in irrigated area, storage would be required in many small watersheds where dry season streamflow is very low or nil. Dry season streamflows in the Zambezi River tributaries are limited, even in the small number of perennial rivers, and it seems likely that it would support only a fraction of the full development potential.

Table 2-4 summarizes the number of major storage reservoirs that presently exist in the Zambezi countries. The number of existing small and medium storage reservoirs is much larger but their number and their current status are uncertain. For example, Mozambique reported that there were about 600 small dams in the country prior to the civil conflict, but it is thought that only about 50 are currently functional. The number in Zambia is reported to be between 400 and 500.

While a limited number of major reservoirs can be expected to be constructed for hydropower, individual multipurpose storages for agriculture and for example domestic and industrial water supply, fisheries, environment, and flood management are expected to be relatively small. Nevertheless, the cumulative increase in open water evaporation

from the aggregate reservoir surface area could significantly increase the total amount of water used in the basin, particularly for irrigation.

ZACPRO 6 model studies showed that the most important water use in the basin—in terms of the impact of development on the hydrology of the basin—was open water evaporation from reservoirs. Unfortunately, there is no systematic assessment of the potential for storage development for irrigation and other purposes on which one could base projections of their cumulative and aggregate impact on total water use. Such an assessment should be a high priority since the development of small dams and reservoirs to improve access to water and improve supply reliability for multiple rural uses is a high priority in the basin countries. It is also one of the key types of quasi-public goods in which government will need to invest in order to support the expansion in irrigated agriculture.

2.3 ENVIRONMENTAL ISSUES

ZACPRO 6 studies found that the environmental sensitivity of the ZRB is low based solely on changes in water consumption (annex B). But when increases in population, increased point and nonpoint source pollution, more dams and reservoirs for hydropower, and other purposes are overlaid with the pattern and magnitude of changes in water use and consumption and environmentally sensitive areas, a number of areas in the basin were identified where increased stress and vulnerability could result in significant environmental harm and loss if management interventions are not undertaken.

Among the most important priority areas are: the Zambezi delta and estuary that have already been adversely impacted by the major upstream reservoirs, including Cahora Bassa, and the declining flow of the Zambezi River; wetlands and biodiversity hotspots including the Barotse flood plain, the middle and lower Kafue River basin, and the Maputa area, southern Lake Malawi, and the Shire River valley; and invasion of exotic species, particularly the water hyacinth in Lake Kariba. In many areas, deforestation and land degradation are already causing soil erosion and sedimentation of watercourses and rivers, the Shire River being one of the most fragile and vulnerable examples. Many of these environmentally sensitive and fragile areas are of substantial economic importance.

Table 2-4 Number of Major Reservoirs in the Zambezi Countries

| | Storage capacity > 1 Mm ³ |
|------------|--------------------------------------|
| Angola | 15 |
| Botswana | 14 |
| Malawi | 1 |
| Mozambique | 12 |
| Namibia | 19 |
| Tanzania | 3 |
| Zambia | 5 |
| Zimbabwe | 25 |

Source: SADC 2003a.

The pressure on these areas will stem from both changes in streamflow and water quality. A strategic basin approach to determining the environmental flow requirements (EFR) for each of these areas should be undertaken before the impacts of any individual project proposals are assessed in order to avoid intersectoral conflict and possibly irreversible losses.

2.4 INTEGRATED WATER MANAGEMENT CHALLENGES IN THE ZAMBEZI BASIN

Figure 2-9 is a generalized schematic diagram of the Zambezi basin that helps to illuminate in a simplified form the important spatial relationships and linkages between sub-basins, features, and potential development areas that, apart from rainfall, have the most influence on streamflow. It also identifies key locations (identified by small circles) where integrated water management challenges are most critical to sustainable development and management of the basin. These locations are where water managers at both the regional and sub-basin—generally national—levels must seek to balance upstream and downstream needs and demands for the utilization and consumption of water (and flood management) and the respective watercourses in a manner that achieves agreed national and regional objectives including environmental sustainability.

One of the unique characteristics of the ZRB is that, with a few exceptions,¹⁴ the main stem of the river constitutes the principal joint watercourse, that is, the key watercourse that must be managed jointly by the riparians if they are to enjoy the full and equitable utilization of the water resources of the basin, which is the goal of the new Zambezi Watercourse Agreement. In turn, agreement on how the main stem will be managed—in terms of say 10-daily or monthly streamflow volume, discharge, or timing—establishes important parameters and boundary conditions for the management and utilization of the tributary rivers that are largely under national management and development. The efficacy of joint management therefore depends on the capacity of each riparian country to determine and plan for all of its development needs in each of the tributaries.

The various points identified in figure 2-9 where major integrated water management challenges

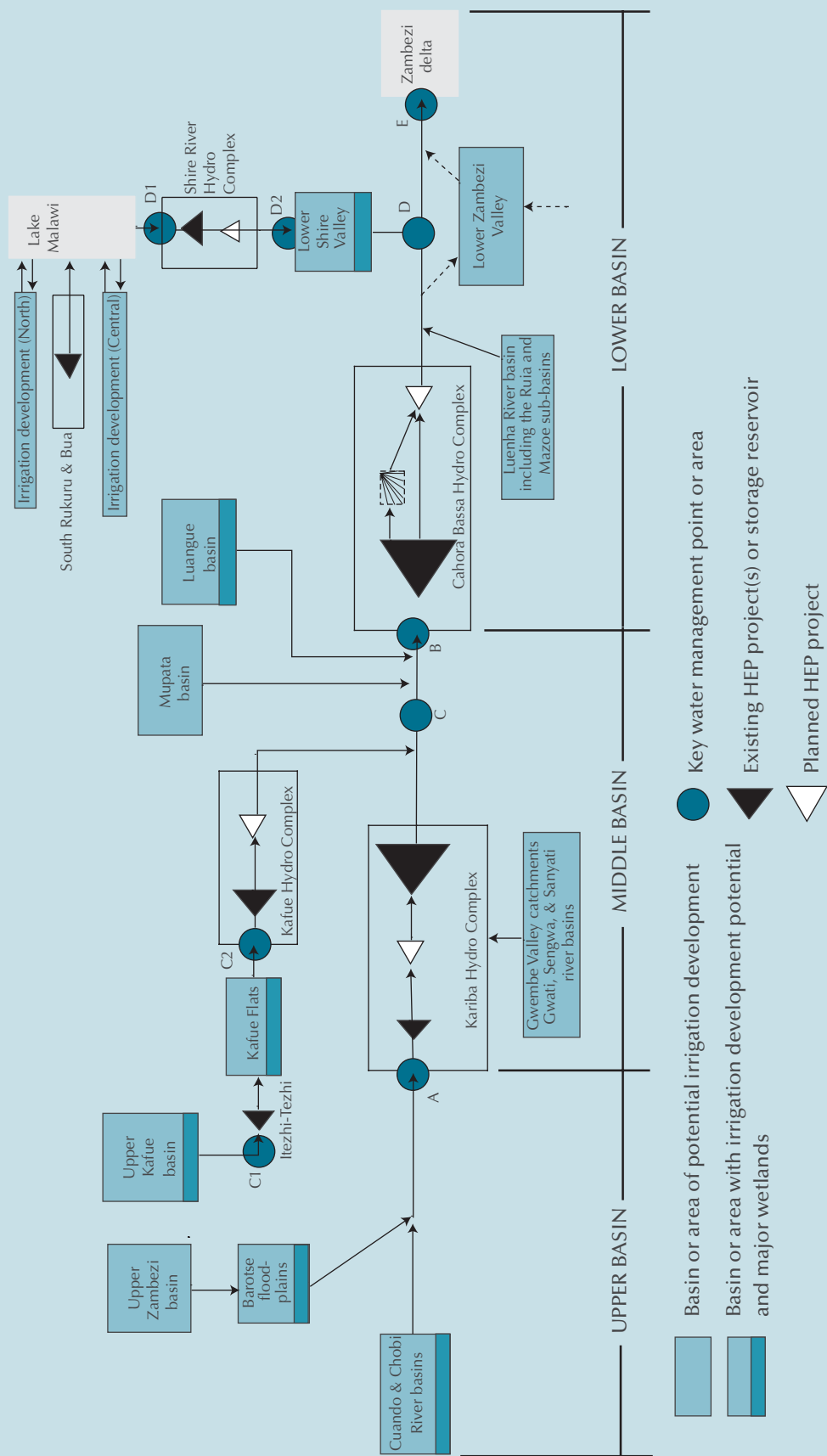
are present are discussed in some detail in annex B, including the economically, socially, and environmentally important Zambezi delta.

2.5 THE CHALLENGES AHEAD

It is worth looking at figure 2-3 once again. Unfortunately for this study, we did not have the tools to estimate the portion of internally renewable and transboundary water resources that are within the ZRB. Nonetheless, figure 2-3 shows that some countries will be highly dependent on transboundary water resources for irrigation development, while for others the contribution of internal water resources to Zambezi basin streamflows, after developing their irrigation potential, will be an important consideration in managing the ZRB. When one adds to this the potential growth in water use in other important sectors, the complexity of joint and sustainable management of the basin, in the context of accelerated national development aspirations and programs, becomes clear. Some of the specific considerations and factors that argue for more diligent and stronger joint management include:

- Most of the streamflow in the ZRB occurs in the single wet season—perhaps 90 percent—and rainfall is often erratic, unreliable, and subject to frequent multiyear low rainfall cycles. The main stem of the river is controlled by the huge reservoirs at Kariba and Cahora Bassa, but the tributary rivers where the development potential is concentrated experience very low or no streamflow in the dry season—even in average years—when irrigation water demand is highest and other needs must also be met.
- The extensive riverine wetlands and flood plain areas in the basin have high economic and social value in terms of agriculture, fisheries, wildlife, and tourism as well as other environmental services, and these are already threatened by water pollution and uncontrolled and unmanaged water use including storage for hydropower generation.
- There are extensive hydropower resources that remain to be developed in the basin that consume substantial quantities of water (current evaporation from reservoirs is about six times irrigation consumptive use) and require well-managed and regulated stream-

Figure 2-9 Schematic of the Zambezi River Basin



Source: Mission estimates.

- flows, pressuring upstream users to restrict withdrawals.
- Flood control, particularly in the lower Zambezi valley, and prescribed flooding in the socially and economically important delta region, require cooperation with upstream riparians including timely exchange of data, improved flow forecasting, conservation of natural flood plain storage areas, and adjustments to how reservoirs are operated to mitigate damages.
 - The riparian countries of the basin have plans for the development and use of water resources for a wide range of economic and environmental purposes. Integrating these growing demands—so that each is able to fully develop its equitable share of the resource without harming the development aspirations of its upstream and downstream neighbors—is an important management task.

Institutional arrangements for water resources management are being created and strengthened in each of the riparian countries, and increasingly irrigation development will be based on a basin approach and well coordinated with basin authorities. Equally, if not more importantly, under the new Zambezi Watercourse Agreement, a new basin level institution, ZAMCOM, will be established. This new institution is needed to establish a framework within which the countries can jointly manage the water resources of the basin. ZAMCOM's role would include:

- Preparing rules for implementing the provisions of the agreement including a framework for joint water management at key locations in the basin (section 2.4) to ensure irrigation, hydropower, flood control, and environmental benefits upstream and downstream.
- Determining environmental flow requirements in the main river network.
- Preparing a basin development plan and strategy that integrates the development plans and aspirations of the member countries including irrigation.
- Supporting the strengthening of national IWRM by growing the knowledge base; developing a shared DSS and the expertise to use it; upgrading the monitoring network; and promoting the sharing of experiences.

The countries each have high expectations that the long period of study and subsequent negotiation to reach agreement on an institutional structure to jointly manage the water resources of the Zambezi basin will lead directly to a period of development in which there is accelerated investment. Given the significant period of time that will be needed to establish a functional ZAMCOM,¹⁵ national initiatives to accelerate water resource development would appear to offer the most immediate opportunity to meet these expectations. It appears that this is quite possible based on the findings of this study and the ZACPRO 6 sector studies, and because of the improved collaboration and communications among the countries that have resulted from the process. The next steps in this regard are discussed in chapter 6.

2.5.1 Building the Knowledge Base

The ZACPRO 6 sector studies also amply demonstrate the current weaknesses in the data available that will make technical negotiations difficult. Building and using a robust knowledge base and DSS that will be shared by ZAMCOM and all the riparian countries is therefore a high priority. Present analytical capacity including the use of models, geographic information systems (GIS), and expanded use of remote sensing needs to be strengthened in the Zambezi countries.

The quality and credibility of the modeling and the data on which the DSS is based will ultimately have much to do with establishing the credibility of ZAMCOM and its counterpart national water resource management authorities. It will also help ZAMCOM to implement key enabling provisions of the agreement, work out options, and make recommendations to the countries that are taken seriously by both policy makers, the private sector, and the donors. But in the early years, poor data and data gaps should not deter technical teams in ZAMCOM or the countries from moving ahead. New data will be forthcoming and the capability and credibility of the work will improve steadily.

It would have been ideal had there been an effort by the Zambezi basin countries to update and maintain the database on which the ZACPRO sector studies were based (called ZACBASE), refined some of the data, and closed some of the important data gaps, and continued the analytical process into the next phase of considering development strategies and options. This, of course, is

not practically possible without an institutional structure like the proposed ZAMCOM in which each of the countries has a stake and an effective mechanism to share in the benefits. This is now possible based on the recent agreement to establish ZAMCOM, and the ongoing joint efforts to work out the details of its implementation. A technical steering committee (TSC) of senior government focal points is presently acting on behalf of ZAMCOM. One could argue that the first few years of work by this nascent organization should

be devoted to building and sharing the knowledge base, updating and improving the database and analytical tools, building capacity within the countries to collaborate with ZAMCOM, extending the analysis of issues, scenarios, and options begun under ZACPRO 6, and beginning the process of implementing the key provisions of the Zambezi Watercourse Agreement. The agreement itself calls for the preparation of a basin development strategy and plan, and work on this has been initiated by SADC and the TSC.

Potential for Growth in Irrigated Agriculture

3.1 INTRODUCTION

This chapter looks at several key factors that influence the scaling up of irrigation investment within the Zambezi basin countries. It rests on the premise that the integrated water resource management issues at both the national and regional or river basin level noted in the previous chapter can be addressed in a timely way by the national water management authorities and ZAMCOM. That will allow a sustainable expansion of irrigated agriculture in each of the countries to be undertaken within the limits and opportunities defined by those management processes. At the concept stage of this study, three questions were raised concerning the strategic issues in the irrigation sector that would be important in shaping strategies to scale up investment in irrigated agriculture in the ZRB. These are:

1. *The need for a major expansion in irrigated agriculture.*
2. *How much additional irrigation should be developed.*
3. *Whether a model for irrigation development is emerging from the lessons learned over the past decade.*

This chapter addresses the first question and part of the second. Section 3.3 examines the potential envelope or upper bound for irrigation development in the Zambezi basin based solely on import substitution to close the cereal staple food production gap, while chapter 4 examines the question of how much irrigation investment should be undertaken.

3.2 THE NEED FOR A MAJOR INCREASE IN IRRIGATED AGRICULTURE

Presently irrigated areas in the Zambezi basin countries total just 3 percent of the arable and permanently cropped land area, and just 6.7 percent of the cereal area harvested (CAH).¹⁶ Within the Zambezi basin, just 3.6 percent of the 5.2 Mha of cultivated land is irrigated. This very low intensity of natural resource use, particularly in light of the very high proportion of the population that is rural and poor, and the overall importance of agriculture sector growth to economic growth, has suggested to many that investment in water resources and irrigation could be a significant and important part of a strategy to accelerate agriculture sector growth and tackle the twin problems of poverty and food insecurity. Four basic arguments are made for increasing the area irrigated in the Zambezi basin countries:

1. *Overcoming high hydrologic risk.* Agriculture throughout much of the Zambezi basin is very risky because of erratic and unreliable rainfall over much of the region and the low percentage of annual runoff that occurs in the dry season (see also annex B). Storage of wet season runoff, management of groundwater recharge, and provision of irrigation conveyance infrastructure provide farmers with improved water control enabling higher yields and production. The previous chapter noted the importance of storage of surface water for agriculture and other purposes (domestic and industrial use, hydropower, flood control, and environmental management), and this is considered again in chapter 4.
2. *Increased productivity.* The average yield of the primary cereal grown in the region (maize), which is about 70 percent of the total CAH, is only about 1.06 Mt/ha, a fraction of the potential irrigated yield of 7.5 Mt/ha. Wheat is still a small crop—less than 1 percent of the CAH—but is of growing importance. The average wheat yield over much of the region is about 1.14 Mt/ha. However, average wheat yields in Namibia, Zambia, and Zimbabwe—where the crop is extensively irrigated—average about 4.6 Mt/ha compared with a potential irrigated yield of about 5 Mt/ha. Sixty percent of the rice in the region is grown in Tanzania with average yields of about 1.9 Mt/ha, compared with potential irrigated yields of 4–5 Mt/ha or more. The average rice yields over the rest of the region are about 1.1 Mt/ha including Mozambique, the second largest rice producer. Thus, there is very large scope for increased production if water is available for timely irrigation and farmers have better water control and modern inputs.
3. *Improved food security.* Because of erratic rainfall, frequent drought, and low productivity, the Zambezi basin countries tend to be chronically short of food, requiring large amounts of food imports and donor food assistance. Hence, national food self-sufficiency has been a frequent goal of most countries in the basin, especially in response to prolonged periods of low rainfall and drought. Despite the sacrifice of economic efficiency this goal entails—potential social and environmental costs, high recurrent foreign exchange cost of food imports and the distortions and inefficiency

of public management of food supplies—this has been an attractive goal to financially strapped governments. Expanded investment in irrigation is frequently seen as the answer because of the evident large yield gains and increased agriculture production that could potentially accrue from expanded irrigation. But as the analysis in section 3.3.1 shows, the combination of improved rainfed yields and increased CAH offset a substantial portion of the requirement for investment in irrigation unless it is driven by market demands.

4. *Poverty reduction.* Irrigation schemes that result in profitable farming raise the income of farmer irrigators, lifting their households out of poverty and subsistence. Profitable irrigated farming also has other direct and indirect benefits that accrue to agricultural labor and the larger rural community, including increased employment, increased food availability, and increased commercial activity that stems from a growing rural economy. This multiplier effect has generally been found to be between 1 and 2.

These arguments, while appealing and seemingly rational, do not in themselves justify increased investment in water resources and irrigated agriculture. Chapter 4 addresses the issue of justifying such investments. The next two subsections look more closely at the linkage between irrigation and food security and poverty reduction.

3.2.1 The Status of Agriculture in the Zambezi Countries

Table 3-1 summarizes some key data concerning the role of agriculture in the respective economies of the Zambezi basin countries. The Zambezi basin countries continue to be largely agrarian, and agriculture output continues to be a vital part of each country's economy. Agriculture accounts for 20 percent to a high of 90 percent (Malawi) of direct exports, and significant additional exports indirectly through agroprocessing and manufacturing industries. In Zimbabwe, about 60 percent of the manufacturing sector is based on inputs from the agricultural sector. The manufacturing and service sectors of these countries are weak, and expanding the production of agricultural commodities that are inputs to new processing and manufacturing industries or stimulate the growth of other services could be an important avenue for economic growth.

Table 3-1 The Role of Agriculture in the Zambezi Basin Countries

| Countries | Agriculture value added | | | |
|------------|-------------------------|-----------------------|--------------------|-----------------------|
| | Percent of GDP | Percent of GDP growth | Percent of exports | Percent of employment |
| Angola | 9 | | 0 | 65 |
| Botswana | 3 | | | 20 |
| Malawi | 37 | | 90 | 85 |
| Mozambique | 24 | 20 | | 80 |
| Namibia | 11 | | | |
| Tanzania | 47 | 40 | 23 | 67 |
| Zambia | 22 | 14 | 19 | 67 |
| Zimbabwe | 18 | 50 | 30 | 27 |

Source: World Bank CEMs, WDI, and related ESW reports. Data are generally from 2000–2004.

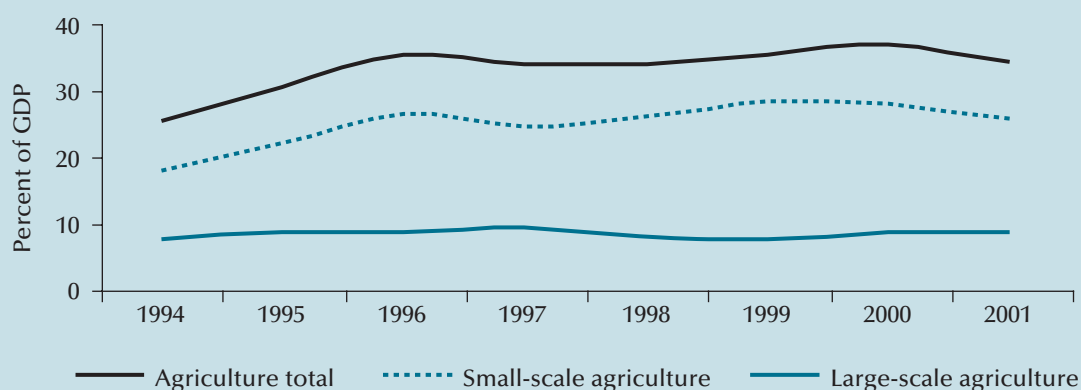
Note: Empty cells denote data not available.

Agriculture growth is also a significant component of GDP growth: 50 percent in Zimbabwe, 40 percent in Tanzania, and 20 percent in Mozambique. Hence, most countries view agriculture sector growth as an important engine of both broad-based economic growth and poverty reduction to the extent that the benefits of this growth are widely shared.

The low level of arable and permanently cropped land per rural person suggests that most rural households average only about 1–2 ha or less. Only in Angola, Botswana, Namibia, and Zambia is the ratio of arable land per rural person above one-half hectare per person. However, extensive farming is extremely difficult in the latter three countries because of poor soils, extremely high ET, widespread arid conditions, and erratic and unreliable rainfall. Nevertheless, smallholders consti-

tute not only the largest group within the farming sector but also a major component of agriculture sector output. In Malawi, smallholder output has been consistently about 75 percent of agriculture GDP (figure 3-1).

The extremely low levels of irrigated land per rural person suggest that irrigation is often confined to the equivalent of household gardens, except near wetlands and seasonally flooded lowlands. Indeed, “informal” irrigation within and along the margins of these wetland areas—generally called *dambos* though there are many different local names—is widely practiced. Land that is equipped for irrigation (777,000 ha) is only about 60 percent of the total farming area where some form of water management¹⁷ is practiced (1,288,000 ha). In Malawi and Angola, this “informal” irrigated area significantly exceeds the area equipped

Figure 3-1 Malawi: Smallholders in the Agriculture Sector as Percent of GDP

Source: World Bank June 2004.

for irrigation, and in Zambia it is 39 percent of the area equipped for irrigation. Because of the lack of irrigation infrastructure, including affordable technology, there is intense competition for access to these wetland areas in the dry season. Since their overexploitation has significant consequences for the environmental services these areas provide, their sustainable development and use should become the focus of efforts for strengthening community management of these areas. Studies of the economic value of wetlands in the ZRB have shown that farming, livestock, and particularly fishing make substantial contributions to the income and livelihoods of the communities that utilized them.¹⁸ All wetland communities have been found to make use of fish, wild animals, palms, grasses, reeds, papyrus, and food plants in addition to water.

3.2.2 Long-Term Agriculture Trade and Cereal Deficits

FAO studies have projected that the value of net agricultural trade in southern Africa¹⁹ between the base years of 1997–1999 and 2030 will worsen for cereals and noncereal food crops, but remain positive (net export) for other food crops, tropical beverages and industrial crops, and livestock and dairy.²⁰ The value of net imports of cereal food crops are projected to increase by a factor of 2.5 between 1997–1999 and 2030 in the southern Africa region. However, the value of overall agricultural trade would remain positive (although declining) because of increases in the value of net agricultural trade in industrial crops and livestock and dairy, and continued positive trade in other food crops.

The growth in livestock and dairy production—and consequent increase in the demand for irrigated feed crops—could be an important factor in the expansion of irrigation. Among nonfood and industrial crops that are mainly exported, coffee, cotton, and tea production are projected to increase substantially. Industrial crops are projected to constitute nearly 70 percent of exports.²¹ Among other food crops, only citrus and other fruit are projected to create a surplus that would grow by over one-third, but since these as well as horticulture crops (vegetables) are nearly all consumed in domestic and regional markets—through cross-border trade within the region—they remain only about 17 percent of the overall exportable surplus.

Of greatest concern to southern African countries is the forecast of the continued dominance of

cereal food crops and the sustained production deficit. About half of the value of agricultural production in 2030 is projected to be cereal food crops, and 45 percent of the projected value of net agricultural imports consists of cereals, sugar, and vegetable oils. Imports of wheat and rice—and a small quantity of maize—would be about half of net imports of food crops in 2030.

Bruinsma (2003), and Westlake and Riddell (2005), utilize a self-sufficiency ratio (SSR) as one measure of projected surpluses and deficits of agricultural commodities. The SSR for cereals in the southern Africa region is projected to rise only slightly from 0.74 in the 1997–1999 base period to 0.81 in 2030, that is, about 20 percent of domestic demand or requirements for cereal food crops in 2030 will be imported. The FAO projections that underlie these figures include increases in irrigated area and yields, but substantial increases in population mean that the shortfalls in production remain roughly the same in percentage terms.

3.2.3 Required Changes in Yields

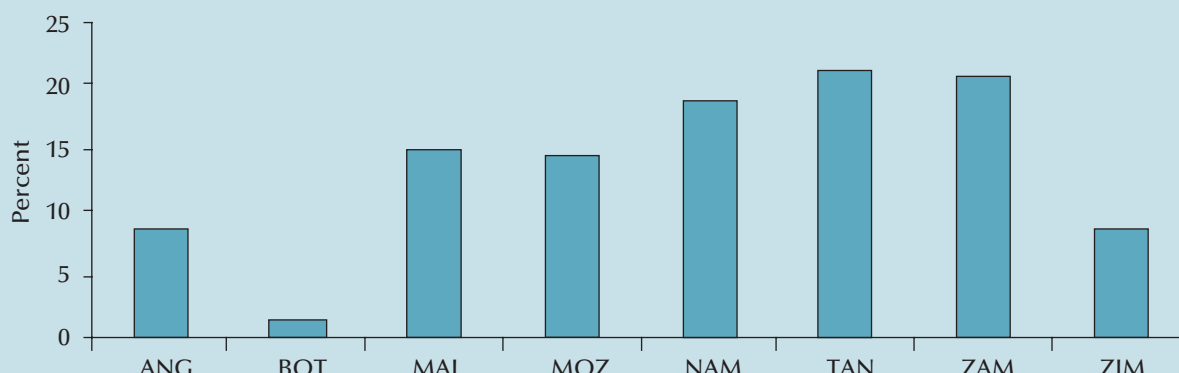
As summarized in the introduction of this section, average cereal yields in the Zambezi countries are very low. Figure 3-2 compares average maize yields in the Zambezi countries with the potential improved yield of 7.5 Mt/ha of irrigated maize. Figures 3-2, 3-3, and 3-4 are based on data from FAOSTAT (2005) and World Development Indicators (World Bank 2005). The highest average yields are only about 20 percent of potential irrigated yields.

Figure 3-3 summarizes the increases in average cereal yield that would be required to satisfy demand in 2005 and 2020 assuming the total CAH remains the same. The changes are substantial, as shown in figure 3-3.

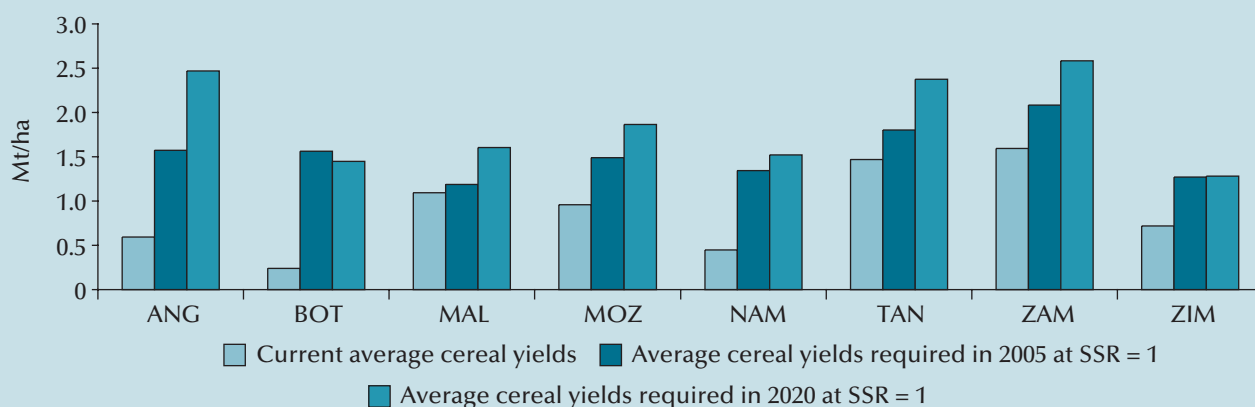
3.3 HOW MUCH ADDITIONAL IRRIGATION CAN BE DEVELOPED

3.3.1 Expansion of Irrigated Area

The discussion in section 3-2 suggests that despite the potential demand for increased production of nonstaple food crops, industrial crops, and livestock feed, the production of cereals is likely to be one of the key drivers for the expansion of irriga-

Figure 3-2 Current Average Maize Yields as a Percentage of Potential Irrigated Maize Yields

Note: ANG = Angola, BOT = Botswana, MAL = Malawi, MOZ = Mozambique, NAM = Namibia, TAN = Tanzania, ZAM = Zambia, ZIM = Zimbabwe.

Figure 3-3 Current Average Cereal Yields and Required Future Yields

Note: ANG = Angola, BOT = Botswana, MAL = Malawi, MOZ = Mozambique, NAM = Namibia, TAN = Tanzania, ZAM = Zambia, ZIM = Zimbabwe.

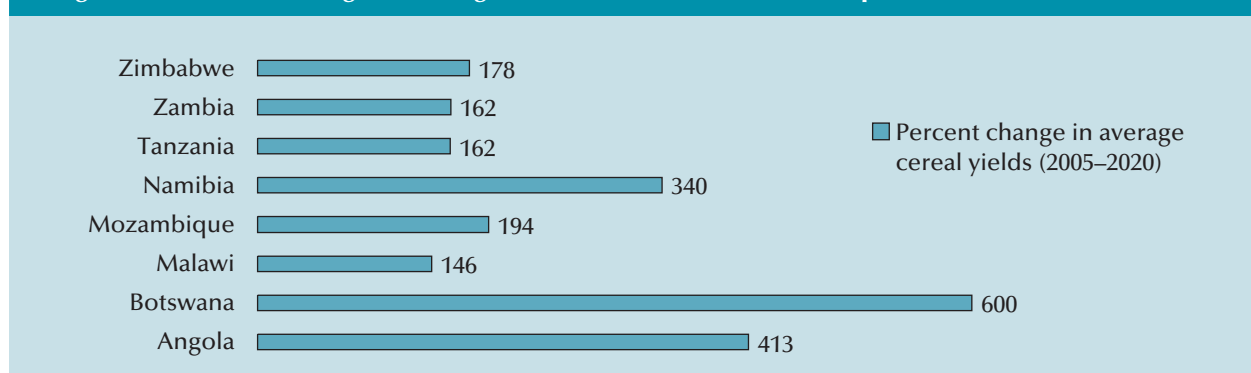
tion. This is of course problematic because cereals have a much lower value than other crops, making it difficult for irrigated farming based primarily on cereal production, to be profitable. These issues are discussed in the chapter 4.

The problem highlighted in section 3-2 is the continuing gap between the demand for cereal staples—principally wheat, maize and rice—and production that is forecasted through 2030, and the cumulatively large import bill this implies. Closing this gap by substituting domestic production for imports suggests one way to estimate the envelope for irrigation expansion—that is, to estimate the maximum amount of irrigation that might be expected to develop. This is of interest at this point in order to assess whether this level of expansion is possible in terms of irrigable land and available

water resources. Whether there is demand for this amount of irrigation, or whether this upper bound is actually profitable and economic, is a different but critical question (see chapter 4).

To estimate how much irrigated area and water would be required to close the cereals gap, we have initially assumed²² the following (all of these assumptions are readily varied):

- The SSR in 2020 is equal to 1 for the forecasted population in the Zambezi basin—that is, cereal demand or requirements in 2020 are fully met by domestic production within the basin (ignoring cross-border trade for the moment).
- Cereal requirements per person are assumed to be 163 kg/cap/year.²³

Figure 3-4 Percent Change in Average Cereal Yields (2005–2020) Required to Achieve SSR=1

- The CAH remains constant.
- Average rainfed cereal yields are 1 Mt/ha and average irrigated cereal yields are 5 Mt/ha.
- Population forecasts for 2020 are taken from FAO AQUASTAT data (2005), weighted by the percentage of a country's land area within the Zambezi basin.
- Estimates of actual water resources available in each country are based on FAO AQUASTAT data (2005), weighted by the percentage of a country's land area in the Zambezi basin.

The results of this calculation are shown in table 3-2 (equivalent to Scenario D in table 3-3). Irrigated areas increase to about 674,230 ha from the low base of only 195,000 ha in 2005²⁴, with an average growth rate of about 32,000 ha per year across the basin. This area is about 13 percent of the 5.2 Mha of cultivated land in the ZRB, of which about 96 percent is essentially rainfed. Water use would increase to 6,742 Mm³, about 7.1 percent of the water available in the ZRB, or about 4.1 percent of the actual water resources available—internally

renewable water resources plus transboundary water resources—in the Zambezi countries and within the basin. Hence, this scenario is possible from the point of view of availability of irrigable land and annually available water resources.²⁵

Table 3-3 shows several scenarios in which the basic parameters of this simple model are varied. A 10 percent increase in CAH results in a 14 percent decrease in the irrigated area with improved rainfed yields. However, expansion of the CAH in many cases would be questionable because it may involve the use of marginal lands including areas with poor soils, highly uncertain or variable water availability, high-risk agroecological areas, and areas with high erosion and land degradation risk. The major variations in required irrigated area and water use stem from variations in improved rainfed and irrigated yields. Improvement in average rainfed yield has a significant impact on the required irrigated area and hence the investment required.

These results strongly suggest that any food security strategy must address the issue of how to

Table 3-2 2020 Potential Irrigated Area and Water Use in the Zambezi River Basin (SSR = 1)

| | Population in the ZRB | Total irrigated area (ha) | Current irrigated area (ha) | Increase (Mm ³) | Water required (ha) |
|------------|--------------------------|------------------------------|--------------------------------|--------------------------------|------------------------|
| Angola | 815,000 | 16,109 | 1,989 | 14,120 | 161 |
| Botswana | 13,000 | 280 | 4 | 276 | 3 |
| Malawi | 14,351,000 | 169,520 | 43,987 | 125,533 | 1,695 |
| Mozambique | 4,609,000 | 91,966 | 11,211 | 80,755 | 920 |
| Namibia | 84,000 | 1,544 | 139 | 1,405 | 15 |
| Tanzania | 1,991,000 | 26,128 | 9,070 | 17,057 | 261 |
| Zambia | 9,518,000 | 227,458 | 34,016 | 193,443 | 2,275 |
| Zimbabwe | 9,346,000 | 141,226 | 70,850 | 70,376 | 1,412 |
| | 40,728,000 | 674,230 | 171,266 | 502,964 | 6,742 |

Source: Mission estimates based in part on FAO AQUASTAT Data (2005).

Table 3-3 Scenarios for Increased Irrigated CAH and Water Use

| Scenario | Increase in CAH (%) | Rainfed yield (Mt/ha) | Irrigated yield (Mt/ha) | Total irrigated area in ZRB (ha) | Water use (Mm ³) | Percent of ZRB water available | Percent of actual WR available |
|----------|---------------------|-----------------------|-------------------------|----------------------------------|------------------------------|--------------------------------|--------------------------------|
| A | 0 | 1 | 4 | 809,076 | 8,091 | 8.5 | 4.9 |
| B | 0 | 1.5 | 4 | 499,768 | 4,998 | 5.3 | 3.0 |
| C | 10 | 1.5 | 4 | 429,042 | 4,290 | 4.5 | 2.6 |
| D | 0 | 1 | 5 | 674,230 | 6,742 | 7.1 | 4.1 |
| E | 0 | 1.5 | 5 | 422,881 | 4,229 | 4.5 | 2.6 |
| F | 10 | 1.5 | 5 | 363,035 | 3,630 | 3.8 | 2.2 |
| G | 0 | 2 | 5 | 207,439 | 2,074 | 2.2 | 1.3 |

Source: Mission estimates based in part on FAO AQUASTAT Data (2005).

raise rainfed yields. Expanding irrigation is just one element of such a strategy since presumably it is much cheaper but not easier to increase rainfed yields. Water harvesting in catchments near rainfed farming areas—coupled with conservation farming and improved inputs (improved seed and fertilizer) and strong extension services—would constitute the strategic thrust of such a balanced program. Since the irrigation development program would be closely linked to basin and catchment management, these two strategic thrusts could be combined into a single program.

These scenario comparisons are useful because they give a sense of the magnitude and implications of different options. However, one cannot simply choose an option from the list in table 3-3. The choice would be arbitrary and fraught with risk unless the costs and economic returns of each

option are known as well as the associated institutional, social, environmental, and natural resource management issues and constraints. With these data and the appropriate analytical tools to model the various options in the basin, one could decide on one of these scenarios (or others that could be formulated) as a long-term target.

These scenario comparisons also do not take into account development options in other important sectors and important tradeoffs that may exist, nor are they based on an integrated and comprehensive assessment of the different water resource management challenges and constraints that may exist under each scenario. To carry this analysis forward one needs a DSS that includes models that would enable one to develop and analyze scenarios with all these considerations integrated into the analysis (see section 2.5).

Table 3-4 Rural Population (2005)

| | Total population ('000) | Urban ('000) | Rural ('000) | Percent rural | Rural poverty (%) |
|------------|-------------------------|--------------|--------------|---------------|-------------------|
| Angola | 14,078 | 5,068 | 9,010 | 64 | |
| Botswana | 1,795 | 933 | 862 | 48 | |
| Malawi | 12,337 | 2,097 | 10,240 | 83 | 76 |
| Mozambique | 19,182 | 7,097 | 12,085 | 63 | 54 |
| Namibia | 2,011 | 664 | 1,347 | 67 | |
| Tanzania | 37,671 | 13,938 | 23,733 | 63 | 39 |
| Zambia | 10,924 | 3,933 | 6,991 | 64 | 73 |
| Zimbabwe | 12,932 | 4,656 | 8,276 | 64 | 75 |

Sources: Population (2004) from FAO AQUASTAT, 2005; poverty from World Bank Country Economic Memorandums.

Note: Empty cells denote data not available.

3.3.2 The Potential Impact of Scaling up Irrigation on Poverty

Table 3-4 summarizes 2005 estimates of total population and rural population. Two-thirds to as much as 80 percent (Malawi) of the region's population is rural, and agriculture is central to their incomes and livelihoods. Overall poverty in the rural sector ranges from 55 percent to 76 percent. The sharp drop in poverty in Mozambique (22 percent in rural areas) between 1996 and 2002 in terms of both monetary and nonmonetary measures (for example, services) has been attributed in part to very low inequality, which enabled the poor, especially the rural poor, to participate in and benefit from growth.²⁶

Table 3-5 summarizes an estimate of the direct and indirect impact of irrigation expansion in the Zambezi basin under scenario D (table 3-3). The estimate assumes that: 80 percent of the beneficiaries are smallholders and other traditional and subsistence farmers; the average farm holding is about 1.5 ha; and there are seven persons per farm household. The premise is that the schemes that make up this irrigated area raise the income of all direct beneficiary farmers above subsistence. The investment would directly impact about 10.1 percent of the rural population in 2020, and if the multiplier for this economic activity is between 1 and 2, then an additional 10 percent to 20 percent of the rural population would indirectly benefit through employment (on and off-farm), lower food prices, increased food availability, and the general rise in rural economic activity induced by the expansion of profitable irrigated agriculture. Hence, 20 percent to 30 percent of the rural population in 2020 would directly or indirectly benefit if the irrigated area were to increase to the level shown in table 3-5. Though the benefits are real enough, the question is

what level of irrigation expansion is justified by both demand and economic and financial returns.

3.3.3 Surface Water and Groundwater Management Issues

One of the important considerations missing from the above analysis is the time distribution of available water resources and water demands. Perhaps 80 percent to 90 percent or more of the estimated water resources occurs as streamflow in the wet season between December and May while in the other six months from June to November streamflow is either rapidly falling or extremely low or non-existent. There are two broad aims of irrigation development in the Zambezi countries: to ensure that crop water needs are met in the wet season, overcoming the vagaries of rainfall and its effect on cereal yields; and to provide the enabling environment for a second, productive, and valuable dry season crop. Achieving the objective of a cropping intensity of 200 percent must therefore depend either on groundwater or on surface water storage of wet season streamflow wherever streamflow is too low and unreliable during most of the dry season.

Groundwater has been the basic resource for domestic water supply throughout much of the region and, hence, has received considerable attention in terms of investigation and data collection. There are substantial reserves of renewable groundwater in Zimbabwe and Zambia, but this resource is very limited in Mozambique and unlikely to be an option for irrigation development except in isolated localities. The same conditions prevail in Namibia where nearly all rivers are ephemeral and groundwater is a critical resource for livestock and for urban and rural drinking water. In Zimbabwe, groundwater reserves are reported to be about 1,800 Mm³, about one-third of

Table 3-5 Potential Impact of Irrigation Expansion on Poverty in 2020

| | |
|---|----------------|
| Irrigated area in the Zambezi basin | 674,230 ha |
| Percent of smallholder and subsistence irrigated area | 80% |
| Number of smallholder and subsistence households | 359,590 |
| Rural population directly benefited | 2,517,127 |
| Percent of rural population (2020) | 10.1% |
| Percent of rural population indirectly benefited | 10.1% to 20.2% |
| Percent of rural population benefited directly and indirectly | 20.2% to 30.8% |

Source: Mission estimates.

Note: Assumes the multiplier effect of irrigation development lies between 1 and 2.

which will be needed to meet projected domestic and industrial demand.²⁷ In mainland Tanzania, estimated recharge is just under 4 percent of the total net water available (precipitation minus ET) or about 3,725 Mm³. Current use for domestic and livestock demand, which depends heavily on groundwater, is about 700 Mm³ (about 19 percent of groundwater availability (National Irrigation Master Plan—Tanzania [NIMP], prepared in 2002). However, competition from irrigation schemes in many parts of the ZRB is growing and groundwater withdrawals in coastal areas are uncontrolled, threatening aquifers with sea water intrusion.²⁸

Apparently, shallow readily accessible groundwater is not extensively available, since most discussions in the region do not speak often about shallow groundwater that is readily accessible with low-cost technology, except in wetland and some floodplain areas where the use of treadle pumps, for example, has spread rapidly. Since groundwater has been shown to be an important source of dry season flow in the ZRB—and a potentially important source of water for domestic, livestock, and irrigation—the management of recharge and the spread of tubewell technologies for irrigation will be important.

Viability of Irrigation Development in the Zambezi Basin

Despite the apparent requirement for increased irrigation in the Zambezi basin for rural economic growth and to close the cereals production gap²⁹ outlined in the previous chapter, the mere existence of potential land to irrigate—and adequate aggregate surface and groundwater resources to support this irrigation—does not entirely answer the question of how much investment in irrigation there should be. The low value of cereals—and the vulnerability of producer prices to exchange rates, import parity prices, and market distortions—makes it difficult for irrigation, based primarily on cereal production, to be profitable. Moreover, development of formal irrigation schemes can be exceptionally costly and the risk is great of overinvestment in terms of foregone opportunities and schemes that do not yield positive economic and financial returns and important rural benefits. This chapter looks at the experience in the Zambezi region concerning the cost and economic and financial returns for irrigation investment. The next chapter looks at the range of key factors that form the general policy, infrastructure, and institutional environment for irrigation development and investment that, in the past, have been decisive in determining its success.

4.1 BACKGROUND

The sense that public investment in irrigation must result in profitable and sustainable agriculture has emerged in the various policy documents developed by governments of the Zambezi countries in the 1990s. These include recent Poverty Reduction Strategy Papers (PRSPs), economic policy and economic revival documents, agriculture sector policy papers, and frequently in water and irrigation sector policy and strategy papers. Indeed, in some cases the documents speak of commercialization of irrigated agriculture, including small-holder irrigated agriculture. Such policies were intended to lead to a shift in the focus of irrigation investment planners toward the identification and selection of schemes that are financially sound at the farm level and sufficiently profitable for farmers to be encouraged to shift to irrigation of high-value crops using recommended cash inputs, including water, and whose economic value added is commensurate with the scale of necessary investments.

This is not a new idea, although as an explicit and consistent core principal in government policy for the sector it is somewhat novel. However, undertaking to make such a shift at the ministry, depart-

ment, and field levels requires appropriate staff, skills, a database that holds, among other things, real data on farm and scheme performance and farmer behavior, and a commitment to utilize these data to evaluate alternative investment opportunities and policy options including incentives.

Research results reported in the late 1980s and early 1990s—based on case studies in many parts of Africa including the Zambezi region—suggest that smallholder irrigated farming can be viable in terms of net financial and economic returns to most crops and to farm labor and land, and that the productivity and utilization of land by smallholders is frequently very high when conditions are favorable. These results suggest that a strategy to promote agriculture sector growth should include, as one of its key thrusts, increasing the development of the smallholder farming sector by increasing and improving affordable access to water and markets, and the provision of irrigation services.

Planning and project preparation studies in the 1990s³⁰ consistently show that the financial returns and economic value added per hectare for smallholder schemes—as well as larger, more commercialized schemes—are substantial and favorable. Where markets are accessible and timely inputs available, the financial returns at farm level are a significant improvement over rainfed subsistence farming. However, in all cases, gross margins sufficient to justify irrigation investments depend strongly on high intensity farming using modern cash inputs, and on accessible markets where

farmers can receive adequate and reliable prices for outputs and timely inputs. Access, in turn, depends on cost-efficient transport networks and mechanisms (for example, exchange of timely information) to link farmers to markets. It is also clear from these data that there are limits to the level of investment cost that can be supported by typical economic returns from smallholder schemes. Therefore, the choice among different types of water source developments and irrigation technologies is critical to the economic and financial viability of such schemes.

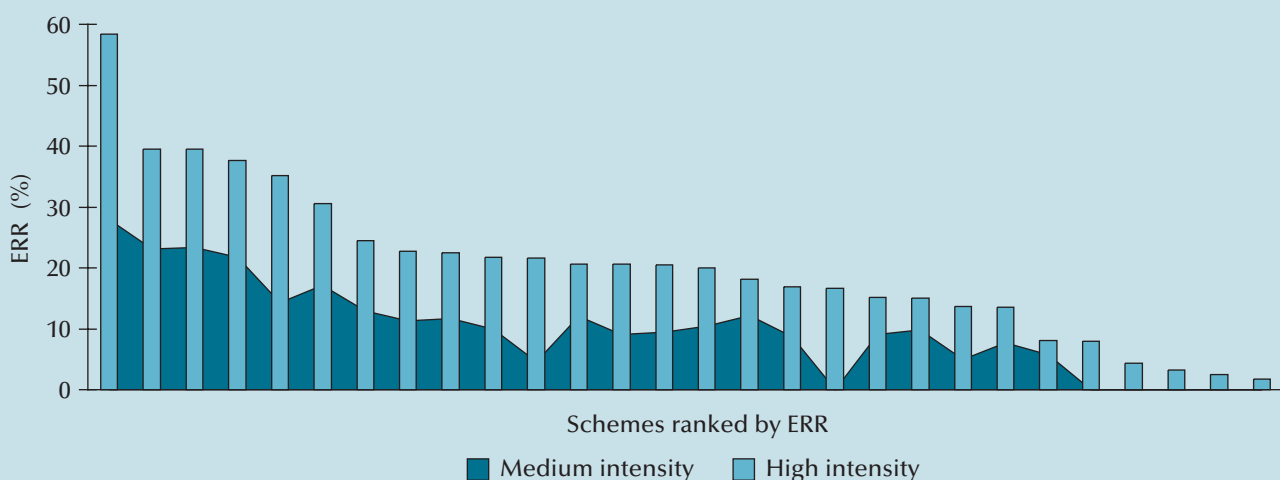
4.2 CASE STUDIES

4.2.1 Malawi: High Intensity Smallholder Irrigation

Figure 4-1 consists of the full array of 28 small-scale schemes that were studied in detail in the Small-Scale Irrigation Development Study (SSIDS, GIBB 2004) ranked or sorted by estimated economic internal rate of return (ERR). Two values of ERR are shown for each scheme: the ERR for a “high intensity scenario” that assumes the use of cash inputs at recommended levels (and good access to markets); and for a “medium intensity scenario” in which it is assumed that little or no cash inputs but high labor input (poor access to markets) are used.

There is a substantial difference between the simulated performance of each scheme under the high and medium intensity scenarios (figure 4-1). Under

Figure 4-1 Malawi: Small-Scale Irrigation Development (GIBB 2004)



the medium or low intensity scenario, only 13 of the 28 schemes meet the success criteria of an ERR more than 10 percent, while 22 of 28 schemes meet this criteria in the high intensity scenario. Figure 4-2 compares investment cost per hectare with the ERR of the same 28 schemes. With a few exceptions, schemes with investment costs per hectare below about US\$4,000 per hectare are viable, and a more detailed review would likely show that the threshold is significantly lower than this figure. All schemes have a significantly lower ERR under the low intensity scenario than under the assumptions of the high intensity scenario. The estimates of financial return at farm level show this most dramatically for the group of schemes bundled into "Project 1" (table 4-1).³¹ Only four of the eight schemes in Project 1 have a positive financial return under the medium scenario, and three of the schemes with negative

financial returns also have a relatively low financial return under the high intensity scenario.

Clearly, in order to achieve the potentially profitable and high economic impact of these schemes, the constraints that prevent or discourage farmers from making the shift to high intensity, higher productivity agriculture must be addressed. Otherwise, experience in the region suggests that utilization of the scheme's infrastructure will drop precipitously to fit the farmers' experience and perception of risk and market potential.³²

4.2.2 Zimbabwe: Economic Returns to Smallholder Irrigation Schemes

Table 4-2 summarizes the results of an assessment of a range of smallholder irrigation scheme types under different assumptions regarding access to

Figure 4-2 Malawi SSIDS: Cost per Hectare and Economic Returns to Small-Scale Irrigation Development

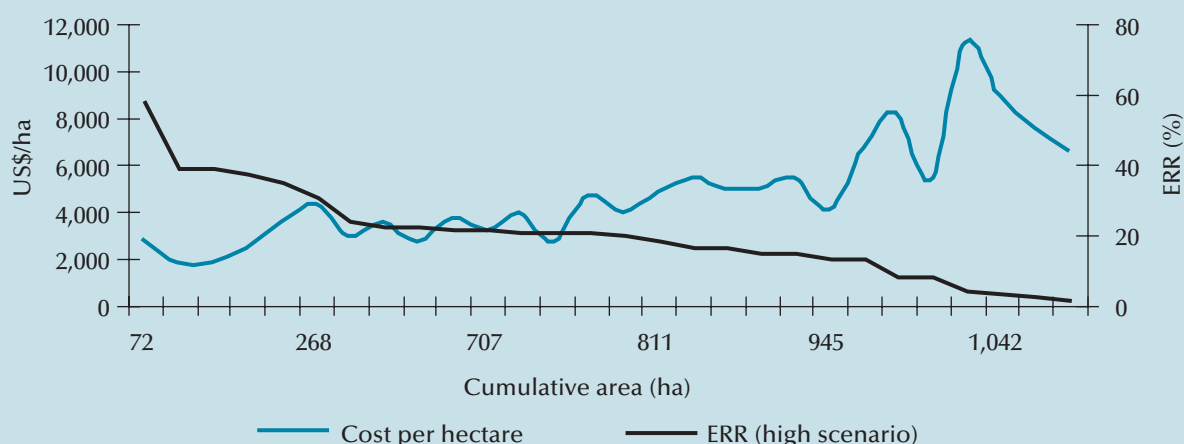


Table 4-1 Malawi SSIDS: Variation in Financial Returns

| Project 1 scheme | Financial ERR (%) | |
|------------------|-------------------|------------------|
| | High intensity | Medium intensity |
| Ibuluma | 27.5 | 4.9 |
| Mabalani | 16.5 | 4.08 |
| Sekwa | 6.1 | |
| Nkhangwa | 12.2 | |
| Lilezi | 26.2 | 10.6 |
| Divwa | 25.3 | 8.8 |
| Lukyala | 5.0 | |
| Luwewya | 6.3 | |

Source: Gibb, Project 1, Vol. 1, Project Design Report 2004.

Note: Empty cells denote data not available.

Table 4-2 Zimbabwe: Smallholder Scheme Economic Internal Rates of Return at Scheme Level (%)

| Scheme type | Upgraded | | New development | |
|--|-------------|-------------|-----------------|-------------|
| | Good access | Poor access | Good access | Poor access |
| Surface irrigation with gravity supply | 74 | 25 | 21 | 4 |
| Surface irrigation with pumped supply | 49 | 14 | 32 | 6 |
| Sprinkler irrigation with gravity supply | 93 | 29 | 22 | 4 |
| Sprinkler irrigation with pumped supply | 35 | 8 | 20 | |

Source: IFAD SISP, Working Paper 10, 1999.

markets and type of investment—rehabilitation and upgrading versus new development—carried out by an International Fund for Agricultural Development (IFAD) team in the course of preparing the Smallholder Irrigation Support Program (SISP) for Zimbabwe (IFAD 1999). Separate cost studies were carried out for each of these types of investment. Differential access to markets was reflected in the economic and financial models by a shift in cropping pattern away from cash crops and lower use of cash inputs. The cropping patterns in schemes with good access to markets included 30 percent horticulture crops while schemes with poor market access included primarily field crops.

There is a dramatic decrease in economic return in the case of poor access to markets for both upgraded and new scheme construction, and economic returns are much lower for new development than for scheme upgrading. The results in table 4-2 show that investments in scheme upgrading (rehabilitation) can be viable with both good and poor market access but that, in the context of this particular model, no

new development should be undertaken where market access is poor and cannot be improved.

Estimates of the investment costs developed for the SISP program are summarized in table 4-3. Estimates of scheme upgrading were about 20 percent of the cost of new scheme development for gravity supply and 40 percent of the cost of pumped supply. Overall, average costs per hectare for surface and sprinkler systems are roughly the same, with scheme upgrading being on average about 28 percent of the cost of new scheme development. These investment cost differences—as well as the difference in operation and maintenance (O&M) costs—are reflected in the large differences in economic return between upgrading and new scheme construction (table 4-2). Since otherwise the schemes are the same—that is, there is no apparent difference, for example, in the reliability and quantity of water supply—it must be the different unit investment costs and O&M costs that are the major influence on scheme viability, all other things being equal.

Table 4-3 Zimbabwe: SISP Scheme Unit Investment Costs (per hectare)

| Irrigation scheme type | Base investment costs | | | | Ratio upgraded/new |
|--|-----------------------|-----------------|-----------|------------|--------------------|
| | Upgraded (Z\$) | Upgraded (US\$) | New (Z\$) | New (US\$) | |
| Surface irrigation with gravity supply | 27,705 | 1,847 | 152,070 | 10,138 | 0.182 |
| Surface irrigation with pumped supply | 36,825 | 2,455 | 88,260 | 5,884 | 0.417 |
| Sprinkler irrigation with gravity supply | 30,415 | 2,028 | 143,550 | 9,570 | 0.212 |
| Sprinkler irrigation with pumped supply | 48,180 | 3,212 | 123,990 | 8,266 | 0.389 |
| Average gravity supply | | 1,937 | | 9,854 | 0.197 |
| Average pumped supply | | 2,834 | | 7,075 | 0.400 |
| Average surface irrigation | | 2,151 | | 8,011 | 0.269 |
| Average sprinkler irrigation | | 2,620 | | 8,918 | 0.294 |

Source: IFAD SISP, Working Paper 10, 1999.

Note: 1998 prices, 1US\$=15Z\$; empty cells denote data not available.

4.2.3 Zambia: Government Smallholder Irrigation Schemes

Zambia is undergoing a major shift from top-down, supply-driven, government-developed irrigation schemes to a more programmatic, demand-driven approach. Among the reasons for this shift are the high cost of schemes in the current portfolio and the persistent failure of past government supply-driven schemes. Consultants to Zambia's Ministry of Agriculture and Cooperatives (MACO) surveyed government smallholder irrigation schemes in the eastern and southern provinces in 2004–2005. These provinces are the only two in Zambia that lie entirely in agroecological zones I and II where the most adverse resource conditions exist for agriculture. Rainfall is erratic—late or early onset of rains, shorter season, long dry spells, overall seasonal shortage—averaging less than 800 mm, with high temperatures in the lowland river valley areas. More than 90 percent of the population of Zambia's eastern province is rural and depends on agriculture subsistence. Similarly, a majority of the population of the southern province is rural and the people also derive their livelihoods from agriculture. The Kafue Flats area of the middle Kafue River forms the northern boundary of the southern province, and the Luangwa River flows through the eastern portion of the eastern province. Table 4-4 summarizes the current development of irrigation in these two provinces, while table 4-5

summarizes the utilization of a sample of five government-developed smallholder schemes in the eastern province and 5 schemes in the southern province. The consultants found that lack of maintenance and lack of leadership and cohesion within the farmer organizations—as well as local conflicts and limited market access—were the principle problems that led to the low utilization.

4.2.4 Tanzania: Smallholder Irrigation Improvement

In preparing an action plan to implement the Tanzania National Irrigation Master Plan (NIMP) (2002), 1,189 existing schemes covering 670,400 ha and 239 new schemes covering 183,900 ha were identified for a total of 854,300 ha. About 83 percent of the existing schemes were a rehabilitation of traditional schemes, and the remainder were water harvesting and the introduction of infrastructure for modern irrigation or improved traditional irrigation. Water harvesting constituted about 68 percent of the new schemes. Since implementation of the master plan involved the implementation of a new irrigation policy and a new participatory approach, 10 model schemes were selected from the inventory to pilot and develop the implementation program. The characteristics of this set of model projects are summarized in figure 4-3 (Tanzania 2002). Eight of the 10 schemes have an ERR greater than 10 percent, and the average cost per

Table 4-4 Survey of Existing Government Smallholder Irrigation in the Eastern and Southern Provinces of Zambia

| Province | Potential irrigation (ha) | Actual irrigated area (ha) | Farmers | | Type of irrigation | | Principal crops | |
|----------|---------------------------|----------------------------|----------------------------|--------|------------------------|-------------|-----------------|-----------|
| | | | Commercial large scale (%) | SH (%) | Overhead sprinkler (%) | Gravity (%) | Sugarcane (%) | Wheat (%) |
| Eastern | 1,684 | 365 | 90 | 10 | 90 | 10 | — | 90 |
| Southern | 40,144 | 20,499 | 94 | 6 | 22 | 74 | 78 | 12 |

Source: MACO, Consultants Report, 2004.

Table 4-5 Utilization of Smallholder Schemes in the Eastern and Southern Provinces of Zambia

| Province | No. of farmers | Potential irrigated area (ha) | Area cultivated (ha) |
|----------|----------------|-------------------------------|----------------------|
| Eastern | 108 | 33.5 | 4.5 |
| Southern | 375 | 434.0 | 63.0 |

Source: MACO, Consultants Report, 2004.

hectare is about \$1,492/ha if the two most expensive cost schemes are dropped (figure 4-3). With these two schemes in the portfolio, the average cost is US\$2,836/ha.³³ Note that the two schemes with an ERR below 10 percent have an average unit investment cost of US\$1,360/ha.

The World Bank River Basin Management and Small-Scale Irrigation Project (RBMSSIP) was designed to implement the approach developed in the NIMP and action plan (World Bank 2004c). However, rather than simply implementing the selected model projects, RBMSSIP adopted a program approach. The program included criteria (see annex D) for project selection and provided support for a multidisciplinary process of scheme identification, selection, planning, and design that would ensure the full participation of farmers. One of the criteria was an upper bound on scheme investment cost of US\$2,000/ha.

Ultimately, RBMSSIP was able to complete 15 schemes out of 735 schemes identified in the two pilot river basins, Pangani and Rufiji. The project closed in June 2004. These scheme improvements covered 5,059 ha at a total cost of US\$10 million or about US\$1,977/ha. These costs included civil works construction, engineering design, and supervision. The project implementation completion report (ICR) for the RBMSSIP³⁴ estimated the ERR for the small-holder improvement component of the program to be 10.4 percent. However, the ICR found that this estimate was sensitive to several assumptions: a sound maintenance regime increases project life from 15 to 25 years and increased the ERR to 12.1

percent, but a 10 percent decline in incremental benefits would decrease the ERR to 8.5 percent.

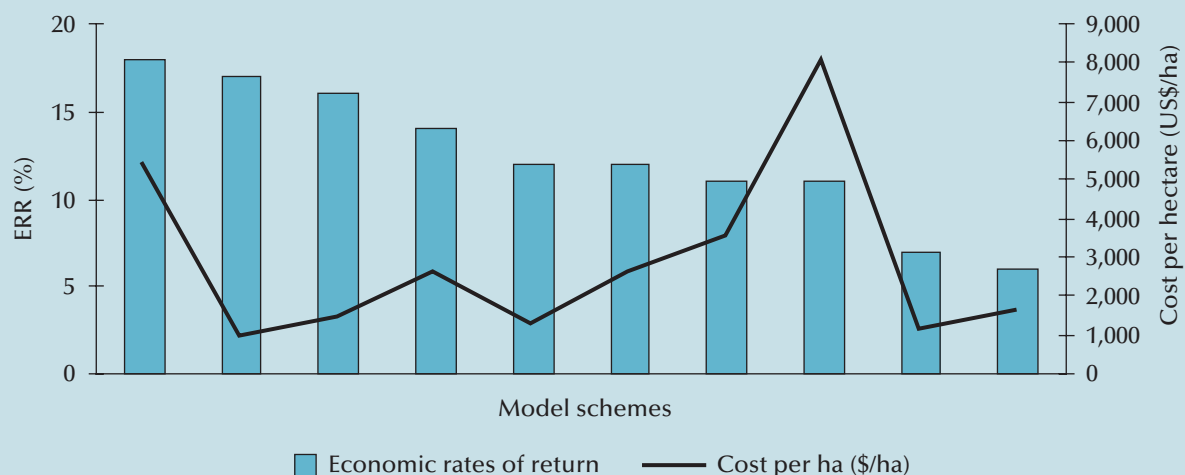
Nevertheless, yield gains by farmers, based on sample cuttings, were substantial. Rice yields rose from 1.8 to 4 t/ha in the Rufiji basin and from 2 to 5 t/ha in the Pangani basin. However, because water is scarce in these basins and competition for water intense—particularly with hydropower use downstream—improving irrigation efficiency was also an important objective of this scheme. Average efficiencies increased from 8 percent to 19 percent in the wet season and from 11 percent to 27 percent in the dry season. The largest improvements were achieved in conveyance efficiencies. When the value—to other direct and indirect uses—of this saved water³⁵ to other direct and indirect uses downstream is taken into account—by allocating the benefits to the scheme improvement component—the estimated ERR increases to 25.3 percent. Hydropower and downstream traditional irrigation were the primary beneficiaries, using between 97 percent and 99 percent of the water savings.

4.3 STORAGE AND IRRIGATION DEVELOPMENT

4.3.1 Mozambique: Small Dam Rehabilitation and New Development Program

The 1992 Mozambique National Irrigation Development Master Plan included an economic analy-

Figure 4-3 Tanzania: Model Irrigation Schemes



sis of proposed schemes limited to the five basins in the southern region of the country.³⁶ The master plan estimated the gross value added per hectare for subsistence farmers, smallholders, medium and large farmers operating commercially, and very high intensity commercial irrigation. The weighted averages of these values, over the five basins for which the analysis was carried out, were: subsistence (US\$391/ha); smallholder (US\$725/ha); medium and large private farmers (US\$1,066/ha); and large-scale intensive farming (US\$2,000/ha). The analysis suggested that the latter value could go as high as US\$3,000/ha.

One of the two New Partnership for Africa's Development–Comprehensive Africa Agriculture Development Programme (NEPAD-CAADP) priority projects for Mozambique is the rehabilitation of existing dams and the development of new dams.³⁷ This project would invest about US\$28,500,000³⁸ in 50 dams over six years at an average cost of US\$570,000 per dam. The project document did not provide any information about the variation of costs with the size of dam or the type of dam or construction.

In this ZRB study, a simple economic simulation model was developed to assess the viability of irrigation schemes that might be developed as a part of this or any other dam rehabilitation and development program. The model links the dam and irrigation system in an economic benefit-cost framework in which it is assumed that: expenditures on dam rehabilitation and construction are spread over three years;³⁹ value added per hectare is as given above; and investment cost for the irrigation system varies from US\$2,000/ha to US\$3,500/ha. ERRs were estimated for a range of scheme sizes from 50 to 200ha. The results show how economic returns vary with investment cost of storage, irrigation investment cost, and gross value added at the scheme level (figures 4-4, 4-5, and 4-6).⁴⁰

Figures 4-4 and 4-5 are based on a low estimate of gross value added (US\$400/ha) that is similar to the low range for both subsistence and smallholder farmers found elsewhere in the region. Two irrigation investment costs are considered: a medium level (MI) of US\$3,500/ha and a low level (LI) of US\$2,000/ha.

- In figure 4-4, only smallholder schemes of 300 ha and above combined with a low irrigation investment cost and medium storage cost of \$285,000 are viable. This storage cost is half the average cost per dam in the NEPAD-FAO project.

- In figure 4-5, smallholder schemes with low unit irrigation investment costs (US\$2,000/ha) and storage costs below US\$285,000 are viable—based on a 500 ha scheme.
- In figure 4-6, the 500 ha smallholder scheme is viable even with medium irrigation investments costs of US\$3,500/ha and medium storage costs of US\$285,000 if the gross value added is closer to the value of US\$700 given in the 1992 master plan noted earlier instead of the lower value of US\$400/ha used in the previous figures.

Both storage costs and unit irrigation investment costs play an important role in determining the viability of schemes, especially when the gross value added is low as one might expect if cereals dominate the irrigation cropping pattern.

Normally medium- and large-sized dams—and to a more limited extent small dams as well—are multipurpose providing rural and small town drinking water supplies, regulation, fishery and flood management benefits, and in some cases even hydropower and downstream environmental benefits. One lesson from this analysis is that in planning new storage investment, planners must allocate costs taking into account all potential beneficiaries in order to be able to evaluate irrigation schemes in a proper economic framework (presuming of course that these other benefits are real, reliable, and sustainable even if they cannot be valued in commensurate terms).⁴¹

A critical planning parameter, especially for small- and medium-sized dams in small watersheds where hydrologic data may be limited or lacking, is the estimate of watershed and reservoir yield (of water) and the probability or reliability of firm water supplies. Yield and reliability are important in assessing the risk associated with investments in irrigation schemes (and other uses) that depend on the reservoir as a water source. The lower the reliability, the more limited is the farmer's response, and the lower is the expected economic return.

An additional reason for focusing on these issues is to highlight the critical importance of multipurpose planning and design of such infrastructure, and to underscore the importance of changing the traditional fragmentation of institutional arrangements that have prevailed in the Zambezi counties. Responsibility for water development—basically public goods water infrastructure such as dams and feeder canals—is vested in one ministry and department, while responsibility for irrigation system development, as well as other

Figure 4-4 Smallholder Scheme Size and Economic Viability

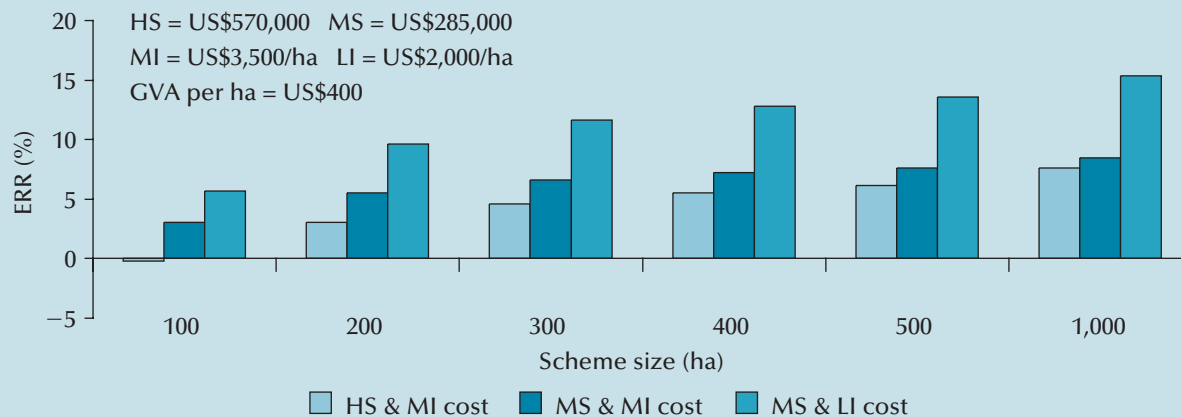


Figure 4-5 Storage Cost and Smallholder Scheme Viability

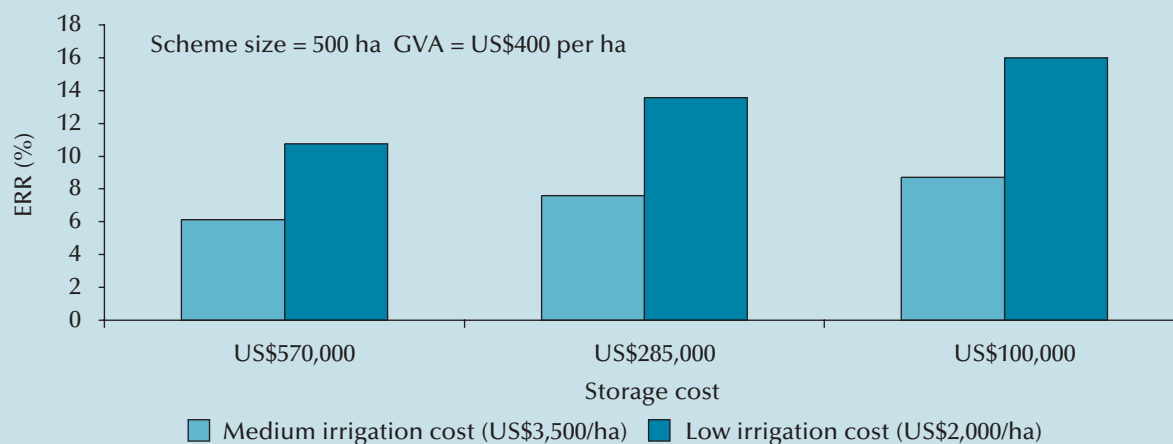
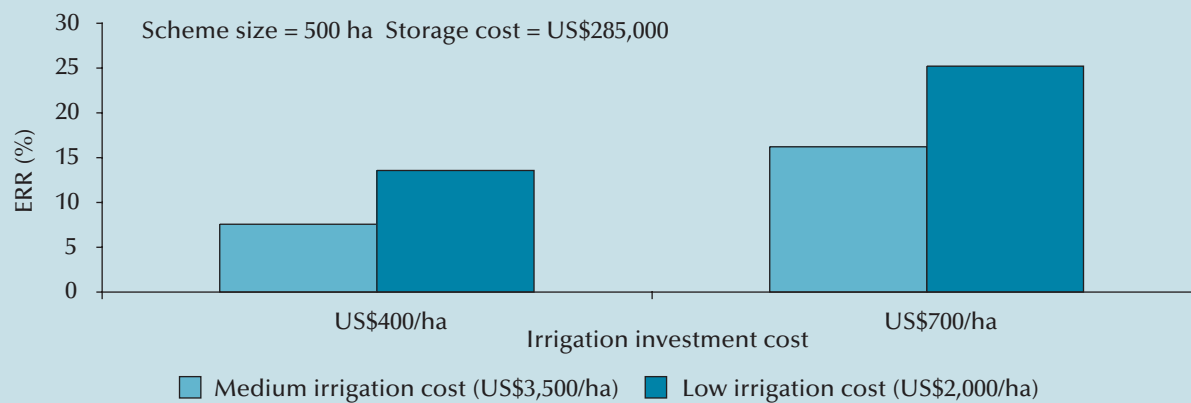


Figure 4-6 Gross Value Added and Smallholder Scheme Economic Viability



water development needs, is vested in another. Coordination and collaboration across departments and ministries is limited and joint planning nonexistent. Under these traditional arrangements, holistic planning and evaluation of investment opportunities does not commonly take place.

4.4 DEMAND FOR PRODUCTS OF IRRIGATED AGRICULTURE

The gross value added of a scheme—so important in the analysis of the case studies in the previous section—is generally the difference between the value and cost of production. Both production costs and output values depend, among other things, on the choice by the farmers of crop and cropping system in a scheme. Notwithstanding the exercise in chapter 3 to estimate an upper bound for irrigation development in the Zambezi basin based solely on the cereal staple food deficit, the farmer's choice of crops depends on: market signals, which may, of course, be distorted by government actions; perception of the risks, particularly concerning the affordability and availability of inputs and the potential output prices; the reliability of water supply; and individual knowledge and confidence.

Westlake and Riddell (2005) have analyzed the trends and opportunities in terms of market prospects for the main crop groups in Sub-Saharan and southern Africa:

- Among cereal staple crops, rice has the largest potential to drive irrigation growth, particularly with the large market demand in RSA. Wheat demand is also forecast to grow substantially and could also drive irrigation growth to a lesser extent when combined with other crops.
- Noncereal food crops such as root crops are unlikely to be an important driver of irrigation growth. Even though these crops have a good yield response to water, they do not travel well (perishable, low value to weight ratio) and, hence, are limited to local and domestic markets that normally clear. They are starting to take off among rainfed subsistence farmers as a substitute for the riskier maize crop in Malawi, for example.
- Among other food crops, sugar has an uncertain future and any growth in production that

relies on irrigation will be determined by private investors. Apart from the emergence of niche markets for horticulture and fruit crops created by private investors—a possible out-grower or contract farming opportunity—demand for most horticulture and fruit crops will continue to be driven by domestic demand and cross-border trade opportunities. While they will continue to have an important place in irrigated cropping patterns, they are not expected to drive irrigation growth at rates beyond population and economic growth.

- The main beverage and industrial crops other than fibers—coffee, tea, and tobacco—are not important drivers of irrigation growth. Cotton however has significant potential to expand exports to regional markets (Republic of South Africa [RSA]) and world markets, and could be an important driver of irrigation growth.
- Livestock output has been projected to grow more rapidly than crop output and it generally has a higher farmgate value than cereal grains. Even though livestock production currently depends mainly on grazing, high growth in livestock output could be a driver for increased production of irrigated feed crops such as feed barley, maize, alfalfa, and other green fodder crops.

In summary, the growth in domestic demand that accompanies economic and population growth will be the primary driver of irrigation growth in terms of the production of cereals, horticulture, citrus, and fruit crops. Among other crops, cotton, rice, and possibly wheat and livestock feeds have the growth potential to also drive irrigation growth. Sugar may or may not demand additional irrigation depending on the outcome of the Doha Development Round and other changes in the structure of world sugar markets. Crops for biofuel production may emerge as a new driver, especially in areas with limited or uncertain rainfall.

Of greatest importance is the enabling environment for private initiative and investment. This can help small farmers through out-grower and contract farming schemes, and by developing markets, market infrastructure, and downstream processing—increasing demand for agricultural products in the farming community—and will create the demand on the part of farmers for irrigation to enable them to effectively enter these new markets.

4.5 FACTORS THAT MOST SIGNIFICANTLY INFLUENCE COSTS

High costs have long been thought to be one of the main constraints to expanded irrigation investment in Sub-Saharan Africa. There are a considerable number of studies that demonstrate that investment in irrigated agriculture, even for smallholders, can be profitable and sustainable if costs can be brought into line with reasonable expectations for the gross value added that can be generated. The brief analysis outlined in the above paragraphs suggests that the financial and economic returns to irrigated agriculture—both farm-level financial returns and scheme level gross margins—are favorable when there is demand for irrigation on the part of farmers, and the external constraints and disincentives can be overcome. Therefore, the question is how unit investment costs in irrigation can be controlled and reduced to levels at which investment in irrigated agriculture is both viable and attractive to the governments and other investors.

4.5.1 Irrigation Investment Modalities

Costs for irrigation vary widely depending on the physical setting, the source of water, and the choice of technology. Generally speaking, the physical or infrastructure interventions would be one of the following four types:

1. *Rehabilitation of existing infrastructure.* This approach takes advantage of the sunk costs of the existing infrastructure by making selective investments to restore its full functionality. It generally requires the least investment cost of all the other types. However, it does have the risk that this functionality will deteriorate again if the reasons why it occurred in the past are not dealt with and corrected. Rapid decline after rehabilitation effectively shortens the life of the assets, raising their annual cost, and lowering the expected ERR. The reasons may stem from the lack of funds for maintenance due to low financial performance of the scheme, lack of farmer ownership of the assets, or lack of leadership and management skill on the part of farmers. In previous government schemes, the lack of government budget for maintenance and the lack of farmer ownership has often been fatal.
2. *Upgrading of existing infrastructure.* This may also involve rehabilitation of existing assets but the aim commonly is to change the infrastructure in ways that not only improve its functionality and performance but also increase its capacity. Traditional farmer constructed and managed schemes are a common target for this type of intervention, but so too are existing schemes whose design or original choice of technology offers an opportunity to improve and increase performance and production. Cost for this type of intervention might be expected to lie somewhere between simple rehabilitation and new infrastructure. Moreover, in addition to having to overcome the same issues noted above, these schemes may create new social challenges since the farmers may have a larger or more complex operation to manage, new farmers to contend with if the area is enlarged, and if investigation of the water source is not done properly, the result may be lower than expected financial and economic outcomes because of water shortages.
3. *New run-of-river schemes.* While typically more expensive than scheme rehabilitation or upgrading, these schemes are often simple and easy depending on the particular physical setting. However, they do pose the same challenges and risks as scheme upgrading outlined above, but since they are new, the social and technical challenges may in fact be much greater.
4. *New storage-based schemes.* These interventions are generally the most expensive, and as we have noted in the last case study in the previous section, and in chapter 2, they require particular diligence in planning to be successful in a financial and economic sense. The dam and head works are commonly treated as public infrastructure, operated and maintained by a basin authority or government department. The public investment cost—or at least the part of it that is associated with public goods—can be treated as a subsidy in the financial analysis of the irrigation scheme, but the full allocated cost is necessary for the economic analysis.

We have not mentioned lift schemes, but these can fall under either types (1), (2), or (3). These types of schemes have been particularly problematic in the Zambezi basin because of the high O&M costs.

Access to energy is exceedingly low in the region, and is scarce and expensive. In the case of the numerous lift schemes developed in the past by governments, the O&M and replacement costs were commonly beyond the means of farmers poorly organized to mobilize the funds from all irrigators. Low lift schemes that rely on treadle pumps, or small diesel pumps (2–5 Hp) have been quite successful in southern Africa and many other developing countries where shallow groundwater or surface water is accessible with these types of devices (the recent extraordinary increases in the cost of diesel fuel, commonly used in these schemes, is probably changing decision making for many small farmers).

However, this type of irrigation generally does not require government intervention except to ensure that there are not market and import restrictions that restrict access to these technologies. It is typically a highly profitable technology. The exception might be when government invests in upstream storage that provides, among other benefits, improved supply reliability for the downstream farmers drawing water directly from the river. Government assistance—through cost-sharing programs to improve secondary and tertiary distribution works—have been effective in improving both the water management efficiency and productivity of these technologies with substantial economic returns.

Storage-based schemes need to be planned in an integrated-basin approach rather than the traditional site-by-site approach. One reason for this is that dams in different parts of a watershed or basin have different physical characteristics and capabilities, different hydrologic properties and impacts, and different potentials for development. There are important economic, social, and environmental tradeoffs between different *systems* of storage in a basin, that is, different arrangements of small, medium, and large dams may exhibit quite different costs and benefits.

4.5.2 Key Determinants of Program Investment Costs

In an effort to investigate and resolve the key issues that appear to have slowed and even halted investment in irrigated agriculture, a collaboration of five donors—including the African Development Bank (AfDB), IFAD, IWMI, FAO, and the World Bank—have undertaken a number of studies including a systematic and statistically valid

investigation of the structure of investment costs in irrigation and its implications for the formulation and development of irrigation projects. This study⁴² collected data from 314 projects in six developing regions of the world, including 45 projects from 19 countries in Sub-Saharan Africa. A total of 52 variables were documented on the basis of project completion reports and corresponding project appraisal documents.

This study found that unit investment cost is an important determinant of ERR and that Sub-Saharan Africa projects with higher unit investment costs tend to have lower ERR. Moreover, it found that the probability of success—an ex post estimated ERR greater than 10 percent—of new construction projects is lower than that for rehabilitation projects in all regions, but the likelihood of success is lowest in Sub-Saharan Africa and Southeast Asia. The probability of failure is higher in Sub-Saharan Africa than in all other regions. The share of successful projects in Sub-Saharan Africa is 56 percent, while in all other regions the share is more than 70 percent with the exception of Southeast Asia.

The average unit investment cost for successful and failed projects in Sub-Saharan Africa estimated by the study are shown in table 4-6. Comparing average unit total cost and unit hardware costs⁴³ in Sub-Saharan Africa to other regions, unit total costs in south and Southeast Asia are significantly lower, but the same costs in East Asia and Latin America are not significantly different. The costs in the Middle East and North Africa region are significantly higher than in Sub-Saharan Africa. Not only are the unit costs of failure projects very high in Sub-Saharan Africa, but they are statistically significantly higher than all other regions. The average unit total cost of failed new construction projects is four times as high as successful projects and more than four times higher for rehabilitation projects. The study concluded that it is the extraordinarily high cost of failed projects that causes the overall average unit total cost to be higher in Sub-Saharan Africa than in other regions.

Table 4-7 summarizes the 10 most statistically significant variables of the set of 52 variables that affect unit investment cost and project success (defined as having an ERR greater than 10 percent). It is interesting to note that the two variables among the 52 that most relate to ownership of a scheme by the beneficiaries—farmer contribution to the funding of the project and farmer scheme manage-

Table 4-6 Average Irrigation Project Unit Costs for Sub-Saharan Africa (US\$/ha in 2000 prices)

| | New construction | | Rehabilitation | |
|------------------|------------------|--------------------|-----------------|--------------------|
| | Unit total cost | Unit hardware cost | Unit total cost | Unit hardware cost |
| Success projects | 5,726 | 3,335 | 3,488 | 2,160 |
| Failure projects | 23,184 | 17,364 | 16,366 | 9,475 |

Source: Kikuchi 2004.

Notes: *Success projects* are those with ERR>10 percent (failure projects have an ERR<10 percent). *Total cost* is all irrigated-related investment including “soft” components such as engineering and supervision, agriculture support, institution building, but not nonirrigation-related costs such as power generation or other nonirrigation infrastructure. *Hardware costs* are total costs less software costs.

ment—do not have a statistically significant effect on either unit investment cost or project success.

This analysis has more to do with how one structures a project or program—including how it would be implemented as well as the selection of components and investments—than it does with how one formulates and designs individual schemes, chooses technology, identifies and responds to the interests and needs of beneficiaries, or the general cost consciousness (capital as well as O&M) of scheme planners and designers.

4.6 RISKS

A program to expand irrigated agriculture in the Zambezi basin will face several risks that singly or in combination could significantly diminish its impact and curtail growth, or simply make it no longer a viable investment. Irrigation itself is a risk minimization strategy for farmers. If sufficient water supply can be mobilized at the right time and in the right amount, yields improve and become more assured, and production and income are increased. This strategy addresses two of the most important risks faced by the farmer—yields and weather—but not the third risk, which is adverse prices both for inputs (seed, fertilizer, labor, machinery) and outputs. Irrigation schemes that are poorly planned and designed often reduce the reliability of irrigation water supplies, or utilize technology that cannot be effectively maintained with the same result. If water governance is ineffec-

tive, water rights may not be secure, further reducing the reliability of supply. Gyration in government policy may lead to macroeconomic outcomes that adversely effect farmgate prices, restrict trade in adverse ways, restrict access to capital or short-term financing, or discourage the private sector from making investments that would have expanded market opportunities and services.

The effect of these various risks is to diminish the success of existing schemes and reduce the viability of proposed new investments. In figure 4-1, we noted that the significant difference in economic returns for the same schemes was due to differences in access to markets. But even with good access to markets, the effect of an adverse combination of the above risks could reduce expected returns in the same way.

The formulation and design of a program to expand irrigated agriculture, and its implementation, can take measures to manage and in many cases mitigate or minimize these risks. The specific array of serious risks that should be dealt with will vary from sub-basin to sub-basin and country to country. In effect, program formulation and design is as much about mobilizing water resources and building infrastructure as it is about minimizing the risks that proposed investments will fail. Given the especially risky conditions for irrigation investment in the Zambezi basin, planners should undertake a systematic assessment of these risks and identify proactive measures to mitigate them in collaboration with economic policy makers.

Table 4-7 Most Significant Factors Found to Influence the Unit Cost of Investment and the Performance of Irrigation Projects in Sub-Saharan Africa

| Project components | Factor | Influence | Unit cost | ERR> 10% |
|--------------------|---|---|-----------|----------|
| Size | Project size | Larger projects that include numerous smaller subprojects or subsystems benefit significantly from economies of scale in formulation, design, and implementation. When there are numerous small subprojects, widely scattered as in most of the Zambezi basin, they should be bundled into the largest project or program possible, consistent with the capacity to manage the program. This factor is significant whether unit total investment cost or unit hardware (construction) costs are considered. | ↓ | ↑ |
| | Average size of subsystem or subproject | As the average size of subsystems or subprojects within a project increases, both unit investment and hardware cost tend to increase, and the likelihood of success decreases, suggesting that projects with numerous small subprojects are more likely to be successful at lower unit cost. | ↑ | ↓ |
| Implementation | Cost over-run | A major cause of the ex post high unit cost and failure (low ERR) of irrigation schemes is a combination of cost over run (degree to which actual cost exceeds appraisal cost), less area irrigated than planned at appraisal, and delays and shortcomings in project funds (GDP/cap being a surrogate for low fund availability). This combination of factors puts a premium on good program management, adequate design, better implementation, and financing schemes that ensure the timely flow of funds. | | |
| | Irrigated area under-run | | | |
| | Gross national product/capita | | ↑ | ↓ |
| Design | Percentage of soft components | The percentage of soft components—technical assistance (TA), training and capacity building, engineering management, agriculture support services, institutional development—has a highly significant influence on unit hardware cost, but a strongly negative influence on project success. The share of soft components in Sub-Saharan Africa (SSA) irrigation project financing is the highest among all the developing regions included in the study. While there is an incentive—indeed a need—for these project components, excessive levels should be avoided. | ↓ | ↓ |
| | Source of water | Sources of water—such as river-dam-reservoir and tanks—do not have a significant influence on unit cost, but have a strongly positive influence on project success, probably because of greater supply assurance. River lift pump schemes have the opposite influence on project success, probably because of the high O&M costs. | | ↓ |
| | New and rehabilitation | New construction of irrigation systems—whether expanding cropped land or converting rainfed land—has a strong positive influence on unit costs and negative influence on project success. Combined rehabilitation and new construction have a strong negative influence on project success. | ↑ | ↓ |
| Objectives | IRDP components | Inclusion of typical Integrated Rural Development Program (IRDP) components in irrigation projects, or irrigation projects implemented as a part of IRDPs, have lower unit costs and higher likelihood of success. IRDP or nonirrigation components often include market roads, drinking water, and community-based income generating activities. However, combining irrigation with power has a statistically significant negative effect on project success. | ↓ | ↑ |
| | Crop and farming system | Irrigation projects that focus on introducing higher value crops—such as vegetables, fruits, and other cash crops—tend to have lower unit costs and a higher likelihood of success than projects primarily focused on cereals, such as wheat and maize. Cereals, as well as sugar and cotton, tend to have higher unit costs, but their effects on success are not statistically significant. | ↓ | ↑ |

Source: Kikuchi 2004.

Farmer Demand, Policy, and Institutional Issues

Given the generally high hydrologic risk and low productivity of rainfed agriculture and the widespread rural poverty, one might expect the demand for irrigation infrastructure to be high. However, that apparently has not been the case, although the real problem may be that no one is listening. There is a long history of smallholders' intensive use of wetland and floodplain areas for dry season irrigation of a wide range of food crops for both subsistence and income, and small traditional farmer-developed and managed irrigation schemes using both surface and groundwater are found throughout the region. Much work has been done by donors and nongovernmental organizations (NGOs) to improve and intensify these modes of irrigation by introducing small-scale, cost-effective technology such as treadle pumps that greatly improve labor productivity, and in some instances to assist groups of these farmers to: improve water management and take up new, higher-value crops; increase access to credit to acquire technology and inputs; and facilitate linkages with markets, especially agroprocessors and industries and large-scale commercial farming operations.⁴⁴ Often it has been a combination of programs from different donors or NGOs focusing on different aspects of the production and value chain that have brought about substantial benefits—underscoring the well-known development lesson that very often infrastructure alone is not the answer.

The problem is that although these programs have demonstrated that such measures have positive financial and economic impacts that lift farm families out of poverty, they have not been replicated on a scale or at a pace that would have the broad agriculture sector growth, food security, and rural poverty impacts sought by the government, despite the evident multiplier effects of these improvements. At the same time, these programs have also demonstrated that a patient, participatory approach is needed for success that is both responsive to farmers expressed needs and provides them with new technology, knowledge, and skills. The process can be slow because of the risk-averse and defensive attitude of farmers as summarized in figure 5-1.⁴⁵

5.1 FARMER DEMAND FOR IRRIGATION INFRASTRUCTURE

An important question is whether a government can or should intervene to spur the pace of expansion of irrigated agriculture and, if so,

how should it accomplish that goal. It appears to be widely recognized in the region that top-down, supply-driven government approaches to irrigation development and expansion have largely failed. In fact, a shift to a more participatory, demand-driven approach has been underway in several of the basin countries for some time, but so far there has not been a systematic and wide-ranging assessment of how well this is going and what lessons have been learned.

5.1.1 New Roles for the Government

Irrigation sector policies in a number of Zambezi countries—in Malawi and Zambia, for example—outline a new role for government as a promoter and facilitator, although it is also recognized that government has an important role in investing in essential public or quasi-public infrastructure that addresses the critical issue of water supply to enable profitable, irrigated agriculture. Therefore, the challenge is to define this new role in practical terms and reshape government's intervention and initiative into a demand-driven approach. As one moves away from the relatively water-rich wetlands and stream banks into dryer land, infrastructure is needed to bring and manage a reliable supply of water to raise the productivity of these lands. Large-scale commercial farmers across the region—with good access to private financing and markets—have built much but not all of this infrastructure to irrigate their land in the past. They have also benefited substantially from favorably located infrastructure such as dams built by the government, and where there are out-grower or contract farming opportunities, smallholders have often captured some of the benefits of these investments. While it is clear from figure 5-1 that there are important policy interventions that could greatly improve the environment of smallholder agriculture and spur growth, not all constraints are easily dealt with in this manner.

5.1.2 Promoting Farmer Demand for Irrigation

Demand can be promoted by improving the policy environment as we noted above, by creating greater awareness of the benefits, and by building trust that these benefits can be practically realized. Trust between farmer and government can be built by government's consistent adherence to favorable

policies, and avoiding the creation of distortions and disincentives. However, to see the problem as one that only concerns the relationship between the farmer and government is to miss the point of the new policy direction. In shifting to a new role that is primarily one of promoter and facilitator, government needs to maintain an enabling environment for greater private sector entry into the sector, and to foster strong links between the farmer and the private sector that do not involve direct government intervention.

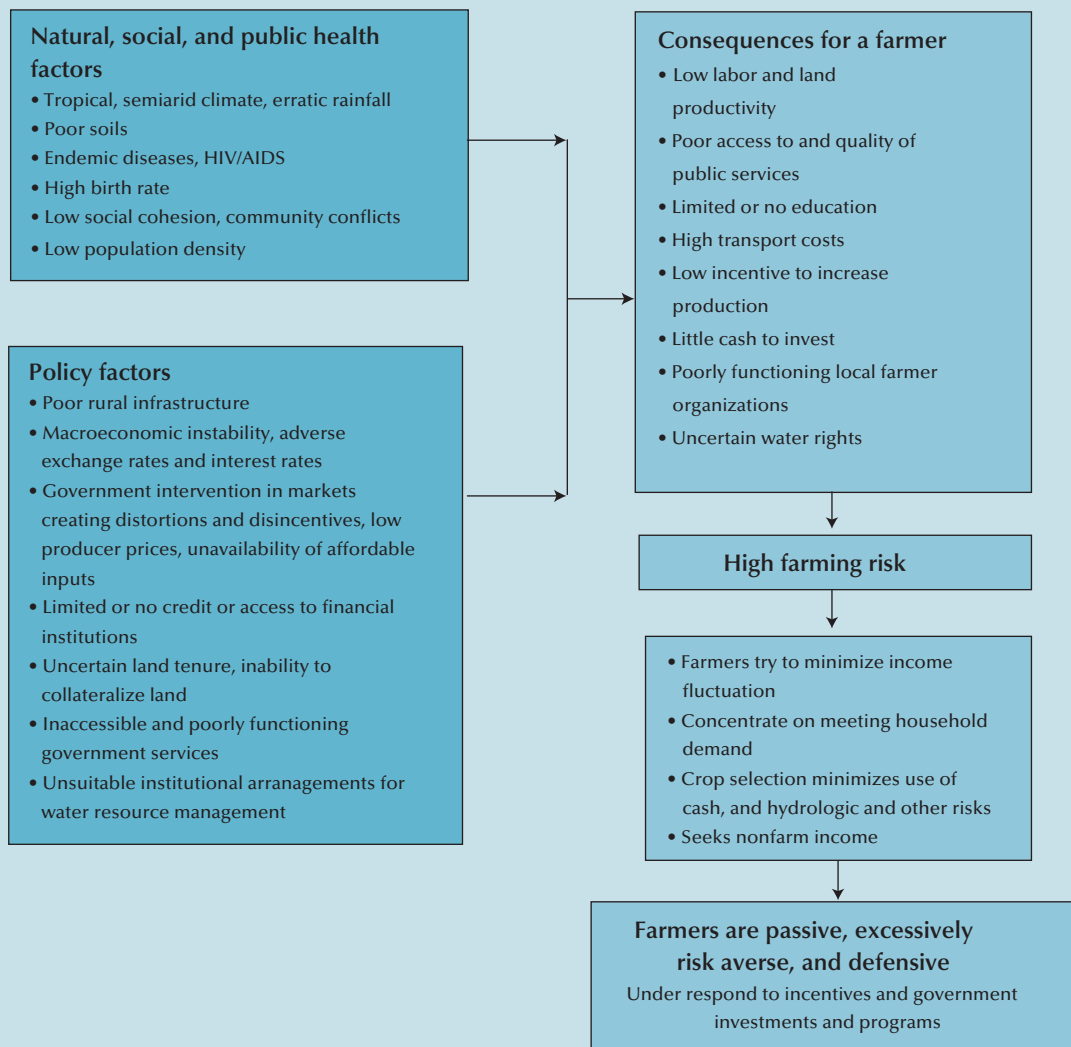
The problem remains how to assess this demand. Beyond a dialogue with farmers to elicit their views and interest (and overcome some of their misgivings), an important measure of farmers' commitment is their willingness to participate in scheme planning and construction with their own resources. Therefore, this is an important step in a demand-driven approach.

A demand-driven approach would have several objectives: first, to ensure that farmers are committed to sustained and optimal utilization of the scheme; second, that farmers are committed to take responsibility for the operation and maintenance of the scheme; and third, that farmers have the capacity (skills and knowledge) and financial means to increase their productivity and shift to higher value crops. The IFAD Smallholder Flood Plains Development Program in Malawi has demonstrated that when the community and farmer beneficiaries are fully involved in rehabilitation and new development, and they feel they are being listened to, considerable commitment and ownership takes place, and this is manifested in the improved productivity of these schemes. In the Tanzania smallholder irrigation improvement program supported by the World Bank, farmers reported that training in crop technology and water management contributed to significantly improved yields.

However, adopting such a new approach involves a major behavioral and mind-set change on the part of government agriculture and irrigation staff. They will require training and new skills to fully and successfully implement their new roles as facilitators of the farmer mobilization process and technical advisors to farmers. In many cases, to be fully responsive to farmers, they will have to give up preconceived notions of what infrastructure is needed, what type of irrigation should be the basis for scheme design, and what crop should be grown.

The scheme planning and design process in a demand-driven approach is more complex since it

Figure 5-1 Factors That Lead to Lack of Farmer Ownership and Defensive Attitude toward Government Irrigation Investment



must balance a wide range of design considerations and factors—efficiency, O&M cost, ease of water management, supply reliability, and others—using not just engineering considerations, but social, economic, and financial criteria and considerations as well. The process of scheme development will in the future have to do not only with the engineering of schemes (although this is essential for scheme success) but also with: communicating with farmers about the potential benefits; creating greater awareness; mobilizing and organizing farmer groups and cooperatives; training these nascent organizations to provide all the necessary skills required to manage their schemes; and supporting the acquisition of new farming skills and knowledge by farmers. Even

if government increasingly relies on the private sector and NGOs to conduct and carry out this process, it will require the same skills to effectively manage these new development partners to the extent they are using public investment funds.

Developing and implementing this new approach is likely to be a major, if temporary, constraint to a rapid expansion of irrigation investment because of the long learning curve on the part of both farmers and government officers. However, the longer-term potential payoff is much higher if it can be made successful in terms of its impact on agriculture sector growth, financial returns to the farmer, and economic returns to government investment.

5.2 FACTORS THAT INFLUENCE PROFITABILITY

Unfortunately, neither engineering or planning skills—nor the efficacy of the processes used for participatory irrigation scheme development—are likely to be the ultimate constraint to the pace and magnitude of profitable irrigation growth. It is more likely to be access to markets and the lack of adequate agricultural and financial services that undermine success.

5.2.1 Inputs

Apart from commercial farmers, input use, including improved seed, fertilizer, and recommended chemicals, is generally very low. Apart from the generally risky environment in which farmers are operating—prices, yields, weather, government policy consistency, water governance and supply reliability, for example—three key factors appear to be important: timeliness and availability, cash, and advice. The lack of credit to finance the purchase of inputs, and the lack of extension services are briefly discussed below. Private sector networks of suppliers have not developed sufficiently to replace public distribution in part because of the high cost of imports, lack of short-term financing and transport costs, as well as the lack of cash and reliable incomes in the rural economy to stimulate expansion and extension of dealer networks deep into rural areas. Farmers who are participating in out-grower schemes and contract farming have benefited from the timely provision of inputs, credit and advice, demonstrating that the private sector can deliver these critical services when incentives are positive—importantly, prospects for sales growth and healthy margins. New ways will have to be formulated and tested to stimulate expansion of private sector activities in input markets to reach more smallholders and subsistence farmers.

5.2.2 Extension Services

Traditional extension services are weak throughout the region and the agricultural research system has all but disappeared. A major expansion of irrigation will require intensive support to help farmers and farmer groups acquire knowledge of efficient water management technologies and new, high-value crops, and cropping practices. If broad-based pro-

ductivity growth is to be achieved, the breadth of advice and service that extension providers must deliver will also have to broaden to encompass not only smallholders with new facilities, and emergent commercial farmers, but rainfed farmers as well. It does not seem to be so much a problem of the number of extension staff, but one of skills and motivation and an efficient research system that can deliver the appropriate knowledge. Moreover, it is not at all clear that government needs to make the large investment necessary to rebuild its public extension system when it can be outsourced to or independently financed by the private sector. Instead, these budget resources should probably be used to rebuild and support the agriculture research system. There is renewed global interest in revitalizing research systems in developing countries and new opportunities for collaboration and innovation in this regard by partnering with such organizations as the Consultative Group on International Agricultural Research and the SADC.

5.2.3 Rural Financial Services

The supply of credit to farmers has shrunk dramatically since financial markets were liberalized in the 1990s. These policy changes eliminated subsidized credit for smallholders. However, high real interest rates and limited supply of credit have made investment in agriculture and irrigation expensive even for large commercial farms. Smallholders—who have inherently high hydrologic risks and lack collateral because of the lack of land title and tenure—have found it extremely difficult to access short-term financing of modern inputs. However, new institutions are appearing that are oriented toward providing financial services to resource-poor farmers and rural entrepreneurs including: out-grower schemes under which farmers are supplied input credits; microfinance institutions that rely on joint liability and community screening and monitoring as substitutes for collateral; and informal credit schemes that operate, for example, among producer, farmer, and community groups.

5.2.4 Access to Markets

The experience of the 1990s shows that farmers will respond by investing in agriculture, shift their cropping pattern, and purchase inputs such as improved seed and fertilizer, if they are reasonably

certain they will be able to sell what they produce at a profit, and the inputs needed to increase yields are available on time at reasonable cost. At the other end of the road, the availability of good, efficient, and accessible market infrastructure—for example, wholesale markets, competitive dealer and trader networks, agroprocessors, and so forth—is limited in the region and has often not been receptive to small-scale farmers. Increasing and improving the linkages and business relationships is essential between private sector agrobusiness, traders, commercial firms, and commercial farmers, particularly smallholders.

5.2.5 Rural Roads and Transport

The lack of good rural roads is a major constraint for smallholders. Remoteness and lack of access leads to less land under cultivation, lower returns per household member, lower returns to land, and less interest in making investments in irrigation. Byerlee and Jackson (2005)⁴⁶ note that in Zambia road density in km/1,000 km² would have to triple from the level in the early 1990s to reach a density that would match India in 1950. In general, high transport costs affect the agriculture sector in important ways, increasing the cost of construction and inputs, and depressing producer prices as the transport premium increases.

5.2.6 Sustainability

Quite apart from the hydrologic risks (floods and droughts, erratic rainfall), economic and food insecurity, and other risks faced by farmers, the issue of the sustainability of water resources and land productivity looms large in many parts of the region already plagued by poor soils and land degradation, especially in Malawi and Mozambique. We have noted the decline in forest cover and the decline in soil fertility. Poor management of soils and land cover (devegetation) and farming of marginal lands is increasing soil erosion, leading to reduced groundwater recharge on which both drinking and livestock water supplies and dry season streamflow depend. These processes are also manifested in silted canals, water bodies including reservoirs, and rivers where the increased silt loads and instability and channel accretion and degradation cause instability and detrimental impacts on downstream users.

5.3 POLICY FRAMEWORK

5.3.1 Shifting Roles of the Government and Private Sectors

If growth of irrigation is to be based on farmer demand, government must adopt a new role as facilitator and catalyst and focus on being an efficient provider of essential, core public goods, such as infrastructure and research and development. Ongoing irrigation policy reforms in the region adopt this stance, but the shift is difficult for government institutions to make without a concerted effort to promote change and build new capacity and skills. At the same time, a gradual process of decentralization is underway, especially in the area of water resources management that will pull other key water institutions toward a more decentralized organization in which resources are more efficiently deployed at the local level, closer to farmer groups and communities. If government is to move away from direct implementation, then it will have to work through partnerships with the private sector, NGOs, and farmer and community associations in such areas as scheme development, service provision, dissemination and adoption of new technology, advisory services, financial services, and marketing. Given the very limited capacity of government departments after a long period of budget stringency and limited investment, even program and project management will need to be contracted to the private sector in many cases in order to extend the government's reach and ensure efficient program management and implementation.

5.3.2 Ongoing Policy Reforms

Irrigation sector policy is changing and adapting to the current challenges (see annex C), but not uniformly across the region. There is a long way to go before the new irrigation strategies that emerge from new policies are translated into institutional reforms and changes, practical programs, and successful actions on the ground.

The core principals incorporated in these new policy frameworks for the irrigation sector include:

- Demand-driven, participatory approach
- Sustainable and profitable irrigation investment and development
- Targeted planning and investment on areas where hydrologic conditions are favorable

and farmers want to develop profitable irrigated agriculture

- Rehabilitated government schemes and newly developed schemes taken over and managed by farmer organizations that will be responsible for their operation and maintenance
- Potential new roles for the private sector in service provision as well as investment

The new water laws in Zimbabwe, Tanzania, Zambia (not yet approved by parliament), and Mozambique incorporate important revisions to water rights systems that will help secure irrigation water supplies, enhance sustainability, and provide for participatory water resource management at the river basin and catchment levels with conflict resolution mechanisms. These laws also establish the principle of payment for bulk water supplies, which has been implemented in Mozambique, Zimbabwe, and Tanzania, and will be a new challenge in Zambia.

Implementing a new policy framework involves organizational and staffing changes that are difficult to undertake, particularly if budget support is not forthcoming. The uncertainty that gives rise to bureaucratic resistance is compounded by the desire of most Zambezi countries to decentralize many functions, including agriculture and water management, to the local level, and to empower local authorities (traditional and new) to manage and undertake these functions. The approach in Tanzania may be the best approach to begin moving up what is a long learning curve. In that country, an action plan was prepared that focused in part on defining a stepwise process to implement the new approach along with a detailed assessment of training needs at all levels, coupled with a well-financed program to pilot and implement the plan and the process.

5.4 POVERTY OF WATER RESOURCE INFORMATION, PLANNING, AND MANAGEMENT

5.4.1 The Knowledge Base

Data, information, and planning services are core public functions. Without these services, it is difficult to imagine how water resources can be effectively managed and regulated in the face of rising

demand across sectors, how sector policy can keep pace with changing social and economic conditions, or how scarce public investment resources can be carefully allocated and targeted to achieve the greatest effect. Some of the consequences of this neglect include the following problems.

- It is not possible to manage a river basin without an adequate knowledge base. With ineffective water management, growth in water demand across sectors leads to less secure water rights and often to less reliable water availability. The consequent increase in the risk to private sector investment in enterprises that depend to a significant extent on water—both within agrobusiness and in other sectors as well—is increased, risk premiums are raised, and in some cases investment is forgone.
- Inadequate attention to the knowledge base for agriculture sector growth, as well as expansion of irrigated agriculture, is partly responsible for the limited access farmers have to agricultural technology and advisory services.
- Public spending on agricultural research in the region is a fraction of the average for Africa. The implication is that neither the public or the private sector is building the knowledge base for the higher agriculture sector growth that they wish to achieve.
- Hydrologic networks and collection of reliable hydrologic data have been seriously neglected with the direct consequence that the analytical basis for making some of the difficult political economy decisions on water allocation and investment the countries will face in the near future will be weak. As a result, decision making will likely be inconclusive and it will very likely delay development.

Targeting of investment and resources is critical to generating early success, but the current *poverty of information and planning* also makes targeting investment and other resources highly uncertain, imprecise, and subject to a wide range of subjective influences, especially from traditional thinking.

5.4.2 Planning

At present, most of the countries of the ZRB are relying on aging master plans and irrigation sector plans for both water management and investment planning. Planning has not been seen by policy makers as either a continuing or important function.

The long neglect of basic planning and resource management data, such as the hydrologic data network, will make it difficult to upgrade and establish good planning functions. There are several important consequences of this condition.

- First, important decisions and policies that enable expanded and sustainable development of water resources (see the previous section) lie unresolved and policy choices are not made because there is both a lack of strong, credible technical analysis and advice and little awareness of the economic consequences of inaction for agriculture and rural development.
- Second, the investment portfolio lacks readiness. The sector doesn't attract investment and the portfolio becomes rigid and out of date and step with changing economic and social conditions and the evolution of government policy.
- Third, the lack of an up-to-date and continuing assessment of water resources supply and demand can have several consequences: conflicts are not anticipated and resolved; pollution exceeds what the resource base can absorb, diminishing the value of the resource; water rights, established under customary or old water laws, become less secure, less valuable, and less useful for production planning (not just to irrigators, but for other uses such as hydropower as well); and important environmental values and services are lost because timing and volume of water withdrawals are not managed and regulated.

The movement toward establishing autonomous, self-financing river basin management authorities, as reflected in sector policy and new legislation, offers the best chance to reestablish and upgrade both the knowledge base and the planning function in an advantageous location close to and with the participation of basin stakeholders. This trend is evidence that policy makers are beginning to realize that growth—in population, the economy, water demand, and water use—is placing pressure on the resource and creating threats to future growth; they recognize that some form of effective management must be put in place.

5.4.3 River Basin Management

In this era of budget stringency, government is generally loath to create new institutions and

increase its recurrent budget. For this reason, among others, governments have agreed to establish new water resource management institutional arrangements, if it can be made financially self-sufficient. It is reasonable to expect this to be the case if water users in a basin value the results and services that such institutional arrangements are designed to provide.

New water resources management authorities that have been established have been given the authority to charge for bulk water supplies. They have also been given water rights administration, permitting authority, and river basin planning and water infrastructure development authority. These new bodies⁴⁷ include the Administração Regional de Águas (Regional Water Administration, ARA) in Mozambique,⁴⁸ Tanzania's Basin Water Offices (BWOs), the Zimbabwe National Water Authority (ZINWA) and its catchment councils, and the Zambia National Water Resources Management Authority and its catchment level bodies.⁴⁹ Since a core function of these bodies is the protection or conservation of the water resources of the basin or basins they are in charge of (which is in their own and their clients interest), they will no doubt begin to become proactively involved in watershed management with the aim of both reducing land degradation and soil erosion (and, hence, reducing downstream degradation of natural channels and infrastructure) as well as managing runoff to enhance groundwater recharge and improve streamflow.

The importance of the authority to charge users for bulk water supply cannot be overstated. Without this source of revenue, these new bodies will be starved by budget stringency and other priorities as they have been in the past, and the critical functions outlined above will not be realized. Central water departments that had many of these responsibilities in the past, have suffered the same budget fate. Moving quickly to establish this revenue stream is important because otherwise policy makers will soon tire of the growing budget burden and lack of ownership by water users, and decide that this new, nontraditional approach is unsustainable before it has had a chance to demonstrate real benefits.

On the other hand, one cannot overstate the difficulty of convincing users, especially traditional smallholder irrigators, that they should pay these charges. Utilities know very well they should pay this cost if the authority is able to manage water supplies and reduce conflict, but they will also try

to minimize both the cost and the potential for large cross-subsidies. Generally in the early years, bulk water supply revenues are unlikely to cover expenses, so a schedule of revision in step with improvements in service and proactive efforts to engage with water users is needed to eventually achieve financial autonomy. One important consequence of this quest for financial autonomy is the need for nonbureaucratic business planning. The expense side of their ledgers cannot become bloated with excessive staff costs and wasteful expenditure. At the same time, staff recruitment, selection, and development requires a new culture of efficiency and productivity matched by motivating compensation.

5.5 RECENT INNOVATIONS IN THE REGION

If one at least broadly agrees with the need and potential for substantial irrigation growth, the challenge for governments in the ZRB to develop new models and approaches that promote the growth of irrigation, particularly among smallholders; incorporate the new policy framework; address the key factors that affect profitability and sustainability; integrate with water resource management; and can be scaled up as capacity and skills are developed and demonstration effects spur demand.

Annex D discusses the main elements of participatory irrigation scheme improvement and development. While there is familiarity and experience within the basin with this approach, the discussion in annex D is included to suggest a framework that governments in the basin can use to review and assess where this process stands today and what timely revisions and new initiatives should be undertaken to successfully promote demand and irrigation growth. This type of diagnostic analysis offers an opportunity for the countries of the basin to collaborate on such an analysis and to share experience and lessons, a process that has been lacking. Without such a mechanism, innovation and lessons do not spread and stimulate new thinking and approaches.

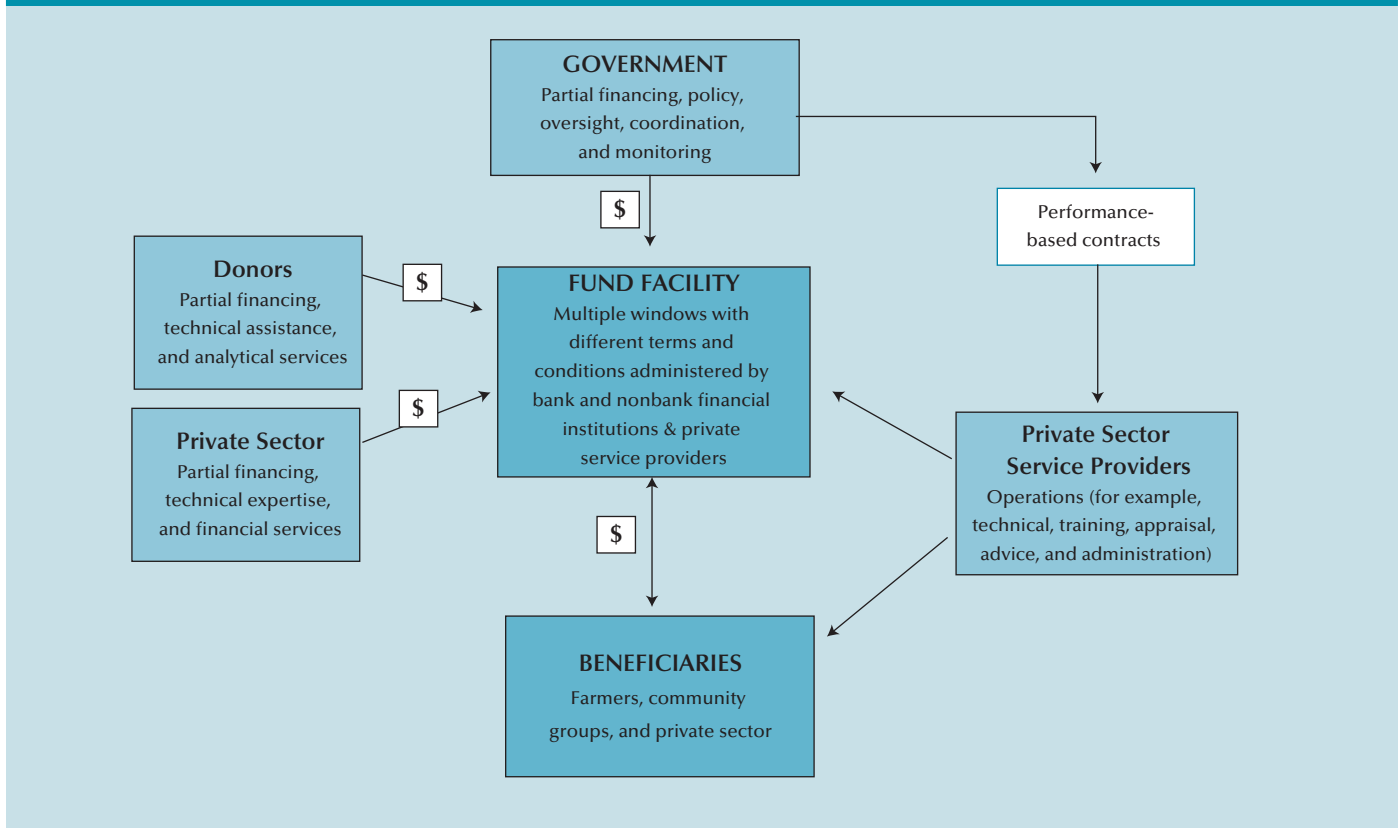
5.5.1 New Financing Mechanisms

Quite apart from the issues and constraints outlined earlier that may limit irrigation growth, the lack of financing for investment in water infra-

structure and for market mechanisms and related capital needs has been a critical constraint. Figure 5-2 outlines a generalized model in which government, donors, and the private sector combine resources and expertise to create one or more financing facilities that are accessible to both farmers and private business active at each stage of the marketing value chain from the farmgate to final products. Such a facility could also provide a mechanism to finance irrigation development by farmer and community groups or government agencies. By placing the facility in private financial institutions, and managing the overall system through outsourced, performance-based contracts, government could avoid past problems of government-managed budget financing.

The new World Bank project in Zambia's agriculture sector,⁵⁰ which is at an advanced stage of preparation, is an example of such a facility. The proposed project would establish a financing framework in which funds are available under a variety of terms and conditions to support improvements in smallholder productivity and income and improve links between producers and markets. It would, in effect, increase smallholder commercialization in Zambia by focusing on improving the functioning and competitiveness of the value chain from producer to final product. It would address the key binding constraints for agrobusiness to develop competitive supply chains and to expand market opportunities for smallholders and other commercial farmers. It would accomplish that by increasing the access to credit, and providing targeted business support and improvements to infrastructure, particularly feeder roads in areas with a high concentration of smallholders linked to out-grower and contract farming schemes. The financing facility would have two elements:

1. *A supply chain credit facility* would provide a *line of credit on a demand-driven basis* including short-, medium-, and long-term loans to finance investments that aim to improve the supply chains of existing and emerging contract farming systems. The facility would enable agroenterprises, traders, and commercial farms working with smallholders to finance capital investments, seasonal inputs, and export activities. Funds are channeled through private financial institutions (PFIs) under the supervision of an apex organization.

Figure 5-2 Water for Agriculture Financing Model

2. *A Marketing Improvement and Innovation Facility* that would provide financial resources on a *matching grant basis* for the development of innovative business linkages between smallholders and other actors in the supply chain, introduce innovative technologies, and demonstrate improvements to a broader audience of supply networks.

5.5.2 An Entirely Commercial Approach

An important challenge for the government of Namibia is to seize the opportunity to utilize its share of the Zambezi, Okavango, and other small rivers that flow into northern Namibia from Angola as an engine of economic and social development within this limited and generally impoverished northern area, which also is the only humid region in the country. The government concluded after much study that most of the past efforts in southern Africa to develop economically and financially sustainable small-scale irrigated farming—especially in cases where resettlement of inexperienced farmers and socioeconomic development were important objectives—had failed

and that it must try a new approach to avoid what it saw as the inevitable dependency of these farmers on long-term government support. In its new model, called the “Green Scheme,” Namibia is attempting to combine both commercial, private sector farm investment, which is presumably strongly market driven, with smallholder resettlement and farming development.

This policy and program seeks to strike a balance between the objective of resettlement of smallholders and landless poor and their socioeconomic development needs with the objective of putting all irrigation on a sound and sustainable fully commercial footing. It does so by promoting a partnership between private investors in commercial agriculture and a specifically recruited and trained group of small-scale farmers who themselves are intended to operate their three-hectare farms on a fully commercial basis. The government will provide a favorable legal and policy framework and provide direct support with appropriate investments and time-bound subsidies.

Having identified an area (which could be a former government-managed scheme or a new area), a source of water supply, and the infrastructure

required to bring water to the farmgate (a gravity or pump diversion and pipeline⁵¹), the Green Scheme Coordinating Commission opens a tender to all investors interested in developing a well-defined area on commercial terms, and invites applications from interested traditional farmers and other candidates for resettlement into the scheme.⁵² The selected private investor and the small-scale farmers would be granted a registered leasehold deed for their farming unit by the Land Board Office in the context of the Communal Land Reform Act.

The Namibian government will impose important but limited service and development conditions on the commercial irrigation farming enterprise. In return, it will offer suitable incentives in the form of controlled access to environmental, infrastructure, and financial resources and facilities. The commercial operator would be obliged to mentor and facilitate capacity building and skills development to the small-scale irrigation farmers associated with the commercial enterprise (the aggregate area of small-scale farming is about equal to the size of the commercial enter-

prise), and provide of agricultural support services (that is, inputs, water, marketing, and distribution) on a cost-recovery basis (at cost without a risk premium). Crops and cropping patterns on the part of the small-scale farmers are not dictated by the commercial enterprise. The small-scale operators are expected to operate their units on a commercial basis and are free to adjust their activities according to their knowledge and perception of the market, except that they may only engage in agronomic activities. The government is also establishing a major training facility that will provide initial 6-month resident training to the small-scale farmers before the scheme becomes fully operational.

In general, the government will finance the costs of infrastructure to provide bulk water supply to the farmgate with agreed water tariffs to be paid by the farmers (phased), but all farm development costs and production costs are the responsibility of the commercial enterprise and the small-scale farmers in the context of the subsidy regime (as outlined in the previous paragraph) finally negotiated with the government.

6.1 STRATEGIC OBJECTIVES

Sustained, higher growth in agriculture value added is a key strategic thrust of both economic revival and poverty reduction in all of the Zambezi basin countries. Agriculture is an important component of GDP and GDP growth, contributes substantially to exports, and is an important basis for expansion of the agroprocessing and manufacturing sectors. Increasing the productivity of the basin's farmers and the total value of agriculture production is seen as a key strategic thrust to achieve this goal. Not only would this underpin higher growth, but if these gains are widely shared they would be a major contributor to resolving the twin problems of pervasive rural poverty and food insecurity, which continue to place heavy recurrent financial burdens on the basin's governments.

The objective of this study has been to identify the potential and modalities for a major scaling up of economically sustainable and environmentally sound investment in water for agriculture in the ZRB. The harnessing of the basin's substantial water resources for irrigation could contribute in a major way to achieving the above goals because it promises large yield gains, mitigates farmer's hydrologic risks, and creates the opportunity to produce water-sensitive, high-value crops in the dry season.

While the study focused strongly on scaling up irrigated agriculture, the analysis demonstrates why a broader and more comprehensive water for agriculture strategy that encompasses rainfed agriculture makes cost-effective and economic sense for the countries in the ZRB. The study shows that a major scaling up of irrigation is possible, but also that the market drivers for such growth are limited, much work will be necessary to foster farmer demand for and commitment to irrigation, and careful attention must be paid to the profitability of irrigation and the viability of investments.

6.2 FINDINGS OF THE STUDY

6.2.1 Managing the Zambezi River Basin for Development

The water resources of the ZRB are crucial to each of the country's aspirations for agriculture sector growth and poverty reduction, as well as growth in other economically important sectors. Analysis based primarily on the ZACPRO 6 sector studies carried out for the

Zambezi basin in the late 1990s (see chapter 2) shows that in terms of average annual streamflow there are ample water resources in the basin to support a major scaling up of water use for irrigated agriculture. Net water use for irrigation could grow from the current 1.5 percent of water availability to about 7.1 percent of water availability if the upper bound on irrigation growth in 2020 is reached. This level of water use is still only about one-third of what is presently consumed by evaporation from hydropower reservoirs in the basin.

While these figures show that in the aggregate in an average year there is ample water available, several factors argue that for this level of water use in agriculture to be sustainable, water resources at basin level and within the major sub-basins will have to be diligently managed.

- First, most of the streamflow in the ZRB occurs in the single wet season, perhaps 90 percent, and rainfall is often erratic, unreliable, and subject to frequent multiyear low rainfall cycles. The main stem of the river is controlled by the huge reservoirs at Kariba and Cahora Bassa, but the tributary rivers, where the development potential is concentrated, experience very low or no streamflow in the dry season (even in average years) when irrigation water demand is highest and other needs must also be met. For this reason, a focus on more efficient use by all users is most important as water demand grows.
- Second, the extensive riverine wetlands and floodplain areas in the basin have high economic and social value in terms of agriculture, fisheries, wildlife, and tourism as well as other environmental services, and these are already threatened by water pollution and uncontrolled and unmanaged water use including storage for hydropower generation.
- Third, there are extensive hydropower resources that remain to be developed in the basin that consume substantial quantities of water—current evaporation from reservoirs is about six times the irrigation consumptive use—and require well-managed and regulated streamflows, pressuring upstream users to restrict withdrawals.
- Fourth, flood control, particularly in the lower Zambezi valley, and prescribed flooding in the socially and economically important delta region, require cooperation with

upstream riparians including adjustments to how reservoirs are operated and conservation of natural floodplain storage areas to mitigate damages.

- Fifth, the riparian countries of the basin have plans for the development and use of water resources for a wide range of economic and environmental purposes. Integrating these growing demands is an important management task, so that each is able to fully develop its equitable share of the resource without harming the development aspirations of its upstream and downstream neighbors.

Institutional arrangements at the basin level.

Under the new Zambezi Watercourse Agreement, a new basin level institution, ZAMCOM, will be established. This new institution is needed to establish a framework within which the countries can jointly manage the water resources of the basin. ZAMCOM's role would include:

- Preparing rules for implementing the provisions of the agreement including a framework for joint water management at key locations in the basin (section 2.4) to ensure irrigation, hydropower, flood control, and environmental benefits upstream and downstream.
- Determining environmental flow requirements in the main river network.
- Preparing a basin development plan and strategy that integrates the development plans and aspirations of the member countries, including irrigation, into a sustainable development framework.
- Support the strengthening of national IWRM by growing the knowledge base, developing a shared DSS and the expertise to use it, upgrading the monitoring network, and promoting the sharing of experiences.

Strengthened institutional arrangements at national level.

This study has argued that effective river basin management and planning are critical functions in support of sustained growth in irrigated agriculture, more broadly to sustainable economic development in the basin countries, and to effective collaboration with their riparian neighbors and ZAMCOM in the joint management of the ZRB. At the SADC–World Bank Zambezi workshop, the countries argued that river basin offices and authorities (both existing and newly established) need greatly increased support to:

build management, conflict resolution, operational, economic and financial, and planning capacity; improve the enabling knowledge base; introduce modern analytical tools; create greater awareness and participation among basin stakeholders; and construct primary hydraulic infrastructure to enable increased and more reliable bulk water services.

6.2.2 Importance of Irrigation in Agriculture Sector Growth and Poverty Reduction

Both land and water resources are ample at the basin level, though water is not always in the right place at the right time. Despite the potentially large economic and social impact of expanded irrigation, achieving high growth rates is problematic because of uncertain farmer demand and profitability.

Potential extent and impact of irrigation growth.

An upper bound on irrigated area in the basin is estimated to be about 675,000 ha in 2020, while a lower bound, based on the ZACPRO 6 studies, is about 290,000 ha.⁵³ Depending on the base one assumes for irrigated area in 2005—about 195,000 ha if irrigated area is growing at a rate of about 1 percent from the ZACPRO 6 1995 base—the increase in irrigated area between 2005 and 2020 would range from 95,000 to 480,000 ha. A medium-growth scenario can be estimated if one assumes that the basin's governments could sustain their estimated current rate of irrigation growth. Such a medium growth scenario would result in an irrigated area of about 464,000 ha in 2020, an increase of 269,000 ha. This medium growth scenario is roughly midway between the lower and upper bound. The implications of these growth scenarios include:

- The potential impact of the high-growth scenario on poverty would be substantial. Direct and indirect impacts would range between 20 percent and 30 percent of the basin's rural population. This impact would be limited to about 14 percent to 21 percent if governments are not able to accelerate the growth of irrigation above what they are currently able to achieve. Despite this large impact, growth in off-farm income opportunities and improvements in rainfed agriculture, including the diversification of livelihoods, remain critically important for higher levels of poverty reduction.
- The cost of the high growth scenario (674,000 ha) would be about US\$1.68 billion plus storage costs if one assumes the long-term average unit investment cost for irrigation is US\$3,500/ha. The medium scenario would cost about US\$942 million over the period 2005–2020, which is less but still a tall order. Investment would average between US\$63 million and US\$112 million per year across the basin.
- Assuming the low gross value added of \$400 per hectare used in the analysis of the viability of irrigation schemes with storage in chapter 4, the ERR for this program would be about 14 percent before storage costs are considered. If the long-run average unit investment costs of irrigation were much lower, say about \$2,000 per hectare, the ERR would be about 26 percent. The latter scenario is probably not possible since one would expect the average unit cost to be rising over time as the availability of more cost-effective and advantageous schemes are exhausted.

Alternative strategies. The above scenarios represent targets that express where the basin countries may want to be in 15 years. But if the goals outlined at the beginning of this chapter are measured in terms of increase in value added in agriculture, food security in terms of SSR, and poverty reduction, then the analysis in chapter 3 suggests that a mixed strategy of irrigation growth and improvements in rainfed agriculture may be less costly, albeit not easier. Irrigation is important to any strategy because of the higher value added per hectare and the opportunity to extend production into the dry season to grow higher value crops that could support export growth as well as enable growth in the agroprocessing and manufacturing sectors. However, we have seen from chapter 4 that irrigation growth may be limited by both farmer demand and the availability of viable investments in profitable irrigation. Hence, the basin countries cannot rely solely on irrigation growth to achieve their broader social and economic goals. The problem for policy makers is to align the agriculture sector policy framework with such a mixed strategy (that is, irrigated and rainfed agriculture), and to sustain favorable macroeconomic conditions that would support the strategy.

As the analysis in chapter 3 has shown, improvements in rainfed yields and modest increases in CAH can have dramatic effects on the level of irri-

gation growth required to close the cereal staple food gap by 2020. The reduction can range from 47 percent to 70 percent depending on the level of average irrigated yields. The introduction of conservation farming and water harvesting with improved seed and fertilizer, and good extension services, can at least double rainfed cereal yields, significantly improving livelihoods and food security. A strategy capable of scaling up improvements in rainfed agriculture has not yet emerged in the basin countries, and finding options needs to be given the same priority as irrigation development.

Market drivers of irrigation growth. One important difficulty in achieving a high irrigation growth rate is that there appear at present to be few drivers of irrigation growth besides import substitution to close the gap in cereal staple food production. Among cereals, wheat and especially rice are expected to be important drivers of irrigation growth. Horticulture crops will continue to have an important role in dry season irrigated cropping patterns, but expansion is limited by the growth of the domestic market and cross border trade. The same scenario applies for citrus and fruit crops. Only cotton and possibly irrigated livestock feeds (feed barley, green maize, alfalfa) are expected to be important nonfood drivers of irrigation growth. Other tropical beverage crops, such as coffee, are forecasted to increase but are not likely to be important drivers of irrigation growth. There may still be room for expansion of irrigated sugar but its future depends strongly on the outcome of the Doha Round of trade negotiations and the future structure of the world market. The lack of major market drivers for irrigation growth may limit the rate and level of growth unless the private sector steps in to create new markets either as industrial inputs (for example, biofuels or soybeans) or direct exports.

Basin approach to irrigation development. Irrigation development would benefit from a basin approach for several important reasons.

- First, if smallholder farmers are to become, in effect, commercial farmers, then they must have the same secure water rights with known reliability that large-scale commercial farmers expect, since this is crucial to effective production planning and increased productivity.
- Second, the active participation of smallholder farmer groups in basin management

(through catchment and basin councils, for example) will tend to enhance the role of irrigation and irrigation farming groups in basin water administration, planning, and decision making, especially in regard to such issues as water allocation, expansion of water use, watershed management, water and soil conservation strategies, and infrastructure development plans.

- Third, the concrete and very favorable experience with this approach in Tanzania, for example, showed that when farmers participate in basin administration and management activities, they develop a stake in the wider issues of water conservation and management, and a greater sense of shared purpose, creating win-win when improved water management and more efficient use of water is an important focus of smallholder irrigation improvement programs.

6.2.3 Storage and Irrigation Development

It seems unlikely that irrigated agriculture could grow from the present level of about 195,000 ha to a level such as 675,000 ha, or to some substantial intermediate level, without the development of significant storage of wet season streamflow and enhanced groundwater recharge. Dry season streamflow in the Zambezi River tributaries is limited, even in the limited number of perennial rivers, and it seems likely that it would support only a fraction of this development potential without storage of the relatively high wet season streamflows for use in the dry season.

- ZACPRO 6 model studies showed that the most important water use in the basin was open water evaporation from reservoirs. Hence, one needs to be concerned about the cumulative increase in open water evaporation from the aggregate surface area of existing and new surface area of reservoirs constructed for irrigation, hydropower, and other purposes.
- At the SADC–World Bank Zambezi workshop, the basin countries suggested that a *paradigm shift in planning ideology* take place. The basin countries suggested that planners focus first on the primary hydraulic infrastructure (storage and conveyance system) and change the traditional approach. This would involve moving away from reliance on site-by-site

engineering studies to a basin approach⁵⁴ in which alternative *systems* of storage and conveyance are analyzed and evaluated considering social, economic, and environmental factors and total net benefits optimized across all sectors including the environment. The planning of secondary infrastructure and schemes to use water for agriculture or other purposes would then be subject to rigorous economic viability criteria, social acceptability and demand, and environmental and financial sustainability. To make this important paradigm shift, support would be needed to expand and deepen the knowledge base, and the capacity to use modern analytical tools and carry out the required surveys, studies, and analysis would need to be strengthened.

- Both storage costs and unit irrigation investment costs play an important role in determining the viability of irrigation schemes, especially when the gross value added is low as one might expect if cereals dominate the smallholder irrigated cropping pattern (see chapter 4). To the extent possible, storage should be multipurpose with cost allocation based on an assessment of the total net benefits and costs of the reservoir, or system of storage reservoirs, to all potential beneficiaries.⁵⁵
- Notwithstanding the creation of basin authorities in many countries of the region, responsibility for water development—basically, public goods water infrastructure such as dams and feeder canals—is still often vested in one ministry and department, while responsibility for irrigation system development, and other water development needs are vested in other ministries. Coordination across departments and ministries is limited and joint planning is nonexistent. The replacement of these traditional arrangements with a new, decentralized institutional framework for river basin management and infrastructure development is essential.

6.2.4 Learning from Past Experience

This study has not undertaken an extensive expost assessment of project and program experience on the ground, although this should soon be done before the scaling up program moves too far along. However, based on discussions with sector officials, donors, and review of documents including

selected project implementation completion reports, the following lessons should be kept in the forefront.

- Programs should address the issues that undermine smallholder profitability at each step of the value chain, and to do this the existing and potential private sector actors must be brought into the program by providing incentives such as favorable policy reforms and access to financing.
- Program financing mechanisms, structured along the lines shown in figure 5-2, would ensure that the program remains demand driven, and does not creep steadily toward traditional, bureaucratic, government supply-driven approaches. The mechanisms would improve the flow of funds to the sector wherever demand has emerged, expand the capacity to absorb higher levels of financing, improve project selection and appraisal, and introduce commercial-oriented discipline on subproject sponsors.
- Cost minimization and cost-effectiveness are paramount in ensuring that subprojects are financially and economically sound as the discussion in chapter 4 demonstrates.
- Governments should outsource the essential technical and social services needed to implement an accelerated program because governments' desires are high and their capacity to administer and manage a scaled-up water-for-agriculture program is extremely limited.
- Governments' capacities to coordinate, manage, and supervise the program must be strengthened. Decentralization remains crucial for the sector in order to locate the most important strategic expertise—irrigation and rainfed agriculture advisory services strongly linked to a revitalized research system—as close as possible to the rapidly expanding number of new smallholder farmer groups.
- Continued training of farmers and farmer groups—in topics ranging from how to lead, manage, and operate their new organization to water management and new crops and cropping practices—has been well demonstrated to be crucial for long-term success.
- Programs must be targeted to maximize the opportunity for early success and demonstration. This will depend in large part on upgrading monitoring networks and information systems and improved planning. The current

deteriorated state of the hydrologic monitoring networks and the lack of planning have resulted in very limited and poorly documented investment portfolios, further limiting the ability to attract investment financing.

6.2.5 Factors That Will Influence the Pace and Magnitude of Scaling Up

While the objective of this study has been to identify the potential and modalities for scaling up irrigation in the Zambezi basin countries, the results constitute a cautionary tale. The economic, social, institutional, and policy context in which investment in a major expansion of irrigation capacity in the ZRB would take place is highly problematic. Importantly, profitability of smallholder agriculture is low, and there are few market drivers present to support rapid and large-scale expansion in profitable irrigated agriculture, especially among the vast numbers of smallholder farmers. Real and steady growth can and will occur so long as demand can be promoted and costs contained. By facilitating and encouraging the private sector to invest in each stage of the agriculture product value chain, including the provision of inputs and services to farmers, new market opportunities may emerge that translate into more profitable irrigated agriculture. In quick summary, there are five critical factors that will most influence the pace and magnitude of scaling up:

1. Market opportunities and linkages (inputs and outputs) that ensure profitable irrigated agriculture.
2. Emergence of substantial demand for irrigation infrastructure and services.
3. Strength of national water resources management authorities to implement participatory IWRM at basin and catchment levels.
4. Government capacity to speed up implementation and put in place an enabling policy environment, as well as a strengthened knowledge and planning function.
5. The private sector's response to the policy environment and new incentives and financing facilities, and their perception of risks and opportunities.

6.3 PROGRAM APPROACH

Financing an irrigation growth strategy should take the form of a program approach. Rather than

beginning with a predetermined or highly engineered set of specific irrigation scheme investments, funding would be provided on a demand basis with well-defined criteria for qualifying specific subprojects and with streamlined procurement procedures. Programs may have a long learning curve and components with long lead times. This suggests that programs be formulated as small and highly flexible, with the idea that as demand rises, and progress on establishing mechanisms and procedures is deemed successful, the program can be expanded.

6.3.1 The Change Environment

Scaling up irrigated agriculture in the Zambezi basin will take place in a complex change environment in which the process of expansion itself and the interventions that are used to support it will reinforce and in part drive that change. As noted in chapter 2, the institutional structure and policy framework for water resource management and regulation at the basin and catchment levels has changed or are changing in Zimbabwe, Tanzania, and Mozambique, where the process has been underway for some time, and in Zambia where it is only beginning. The adoption of the Zambezi Watercourse Agreement, which would establish ZAMCOM and enable joint management of Zambezi River water resources, is progressing.

New irrigation sector policy has been adopted or is being formulated in most Zambezi basin countries. Major changes more directly concerned with irrigated agriculture are being tested in such areas as the mobilization and empowerment of smallholder farmers. Shifts in the role of government, and the emergence of important new players and mechanisms all along the smallholder value chain, are being promoted in such areas as the provision of financial services, access linkages to markets, input provision, extension services, and farmer training and support. Hence, programs should have a strong focus on policy and institutional reform and capacity building.

6.3.2 Program Targeting

A common complaint of past and some current government efforts to promote investment in irrigated agriculture is the lack of targeting on locations where agroecological conditions favor success, on locations where farmer demand is demonstrable, and locations where arrangements

for sustainable water resource management are in place or will soon be in place. Early success is important for a program to generate demand through demonstration effects,⁵⁶ to complete successful pilots of innovations, and to attract increased financing and support from policy makers.

Targeting should be based on substantive planning and analysis of opportunities and risks. The framework to begin such a process could be the national irrigation development concept plans proposed as the next step in following up this study (see section 6.4). However, from a Zambezi basin perspective it would appear that the broad target areas outlined below should be the focus of attention. Some sub-basin areas are in a more advanced state of readiness than others, including the lower Zambezi valley in Mozambique, the Kafue River basin in Zambia, and the Caprivi Strip in Namibia. Others require varying amounts of preliminary planning and analysis, or possibly a preparatory phase of program support.

- Lower Basin
 - *The lower Zambezi valley in Mozambique.* Preliminary planning by the GPZ could provide the basis for preparation of a plan and formulation of a program. Establishment of the regional water authority (ARA) covering this area is underway with EU support.
 - *The lower Shire River valley in Malawi.* This area appears to offer the greatest opportunity for Malawi, but there are no institutional arrangements in place for water resource management nor is there a clear plan for development. This suggests that the initial phase of the program would be to fill these gaps and build capacity.
- Middle Basin
 - *The Kafue River basin and Lusaka peri-urban areas in Zambia.* Zambia needs to pass the proposed water law and quickly establish the Kafue water authority. However, enough may already be known to formulate an initial phase of a program while a more comprehensive and integrated plan is developed.
 - *Zimbabwe.* It is unclear what Zimbabwe's strategy will be as it recovers from the Fast Track Land Reform Program (FTLRP). However, as indicated in the World Bank agriculture growth strategy paper, the early emphasis is likely to be on rehabilitation

and on restructuring of existing irrigation infrastructure for new farmers and farmer groups. At the same time, Zimbabwe has expressed the desire to move ahead on its storage development program. Work on a new strategy and plan would be an essential preparatory step to program formulation and development.

- Upper Basin
 - *The Caprivi Strip area in Namibia.* The program focus could be implementation of the Green Scheme.
 - *The eastern Botswana areas that can be reached by the Zambezi River.* As a first step, the master plan for agricultural development of this area could be evaluated.
 - *Angola.* Implementation of proposals presented in the World Bank's recent agriculture sector strategy paper⁵⁷ would set the stage for program formulation.

6.3.3 Elements of a Program Approach

The main features and characteristics of a program approach are outlined below:

- Programs are guided by an agreed strategic plan with well-defined, long-term objectives and targets; a sector financing framework; and agreed objectives and targets for each phase since the program is performance based.
- Subprojects are planned and selected according to agreed criteria, and targeted on selected basins and catchments.
- Flexibility and adaptability are built in to enable rapid response to experience and new knowledge. Hence, programs commonly have strong monitoring to guide program implementation and adaptation.
- Strong capacity-building and reform agenda (basin management, irrigation development planning, program management) is included.

6.3.4 Program Investments

Annex E outlines the scope of possible program investments to support an irrigation growth strategy and plan in the Zambezi basin. These include:

- Investment in water infrastructure would be supported ranging from rehabilitation and upgrading of existing schemes to new scheme construction. Investment in primary,

multipurpose hydraulic infrastructure would also be supported.

- Subprograms would be supported that aimed at awareness building, mobilization of farmers, support for nascent farmer irrigation organizations, participatory scheme planning and design, and longer-term farmer and farmer organization support.
- Establishment of new financing mechanisms and partnerships with the private sector would be supported.
- Investment would be supported in agricultural research, development and innovative dissemination, introduction of new planning technology, improvements in the water resource knowledge base, and strengthened planning.
- Policy reform, institutional restructuring, and capacity building would be supported.

6.4 NEXT STEPS

The study findings and program approach outlined above were broadly agreed upon with the Zambezi country representatives at the SADC–World Bank workshop in March 2006. The country representatives expressed a strong desire to continue their collaboration to jointly develop a regional plan for irrigation development that would provide a framework for accelerated irrigation development in their respective countries. They saw three immediate advantages to this collaboration: first, it is an opportunity to deepen the integration of irrigation, agriculture, and IWRM; second, it provides a mechanism for exchange of experience, lessons, and innovation that has been lacking and will be needed to support implementation; and third, a regional framework for irrigation development was seen as essential for attracting major international financing. Nevertheless, they also saw this regional framework as emerging from the integration and analysis of national plans.

The discussion at the workshop, as well as this study, indicates that a single approach or strategy will not suit all countries. The strategy and approach to program formulation will be different from country to country because of differing states of readiness, and because of differences in opportunity, physical circumstances, past development, and capacity. Nevertheless, the principles in the study findings outlined above provide a common and agreed upon base from which to work.

6.4.1 Immediate Needs

From this perspective, the countries agreed on two basic critical needs:

- *A regional action plan for the development of irrigated agriculture.* This plan is intended to be a critical input into the Zambezi multisector strategic plan called for in the Zambezi Watercourse Agreement and presently under preparation by ZAMCOM and SADC. This regional action plan is seen as the essential regional framework within which national investment programs to strengthen IWRM and scale up irrigated agriculture can be prioritized, sequenced, and concrete programs formulated. However, the first step in arriving at an agreed upon regional plan is the preparation of national level strategic plans for the Zambezi sub-basins.
- *An irrigated agriculture Program Support and Preparation Unit (PSPU).* Business as usual on the part of donors and governments in the region was seen as an unlikely way to move forward in a timely manner. The countries agreed with the concept of establishing a PSPU dedicated to supporting and assisting with the preparation of plans and programs in each of the basin countries. What is needed is a concentration of resources, effort, and expertise to overcome bottlenecks, assist with the completion of essential preparation activities, and assist with the formulation and design of “bankable” programs. The PSPU would provide a focal point for this effort. The PSPU would:
 - Assist countries to prepare and translate strategic irrigation development plans into “bankable” programs and projects for investment. The goal would be creation of proposals in a shape that can be quickly appraised by a donor.
 - Provide and mobilize TA, and related analytical and advisory services, to support the program planning and preparation process, policy reform and institutional restructuring, and capacity building.
 - Function within ZAMCOM and national frameworks.
 - Gain support by multiple donors. Financing of outputs (program and projects) could be provided by any suitable donor. The PSPU could be a small professional unit eventu-

ally based in the region, possibly as an adjunct to ZAMCOM.

6.4.2 Road Map

To avoid the postworkshop inertia that commonly afflicts such good intentions, the Zambezi workshop agreed on a step-by-step road map. A time frame of one year was agreed to complete the regional action plan, including its review by ZAMCOM, and a detailed schedule was formulated and agreed upon. The group present at the workshop was suitably expanded to ensure representation by all countries—two countries were not present due to logistical problems—and adjusted to ensure that water resources management, irrigation, and agriculture were well represented. The group would meet again at least twice during that one-year period: first, meeting in the mid-term in the process to review progress, options, and issues; and second, meeting to review the integration of national plans and alternative proposals for a regional strategic plan. The process involves the following steps:

- *Preparation of a concept note for the preparation of national plans* for Zambezi sub-basins. SADC agreed to prepare a draft CN in collaboration with the countries and the World Bank. These national strategic concept plans would rely on existing plans and data, and would be formulated quickly in outline form with the data necessary to place them into a regional context.
- *Preparation of a CN to mobilize support* for the process to be drafted by the World Bank. The support would include:
 - Assistance to the countries to prepare national action plans
 - Development of a DSS model and GIS to integrate national plans, and assess options and alternative regional plans
- *Completion of national strategic concept plans* and regional analytical framework. This will be done by the countries but assistance was requested from SADC and the World Bank.
- *Preparation of a draft CN for the establishment of the PSPU* to be finalized after discussions with donors and the governments. The World Bank is responsible for drafting this CN.
- *Preparation and review of options for regional plan.* At the second meeting of the group, these options would be reviewed and dis-

cussed in detail, and an agreed upon plan submitted to ZAMCOM. This process may involve revisions to the proposed national plans and it may involve considerable iteration, but the analytical tools are expected to facilitate this process. The World Bank—with assistance from ZACPRO 6, specialists from each country, and SADC—will be responsible for this analytical process.

6.4.3 Near-Term Needs

There are some key areas where important knowledge is lacking for program formulation and design. These investigations could take a number of forms and could directly involve specialists from the regions. They include:

- *Strategy for scaling up improvements in rainfed agriculture.* The issues and, in most cases, options for making these improvements are generally well known, but there is not a workable strategy for scaling up the numerous small-scale pilots and initiatives that have been undertaken by donors, NGOs, and others in different parts of the region.
- *Institutional and policy assessment.* The social, institutional, and policy setting processes of this initiative are likely to be decisive in determining its success. What is known about the potential stakeholders and the social impact of improved and expanded irrigation is, at best, fragmented and unsynthesized onto policy and program advice, if it exists at all. The issues, capacity, and capability of existing institutional arrangements with government have not been assessed in a systematic manner, and the key lessons and guidance drawn to support program formulation and design are lacking.
- *Mitigating risks.* As highlighted at the end of chapter 4, irrigation development mitigates only a portion of the array of risks faced by programs and farmers. A study should be undertaken of how programs can mitigate risks that threaten their success.
- *Market demand and comparative advantage.* A number of FAO studies have been useful in identifying the potential sources of market demand for the products of irrigated agriculture. The results of those studies are cautionary at best and suggest that a deeper look, within the Zambezi basin, at market poten-

tials, constraints, and each countries' comparative advantage would provide essential guidance to shape irrigation development priorities.

- *Farmer demand for irrigation.* Although the presence of farmer demand, or the capability of governments to foster and facilitate this demand, is of decisive importance, little is known of how much demand is really out there, what specific factors are acting to suppress or promote demand, and how well gov-

ernments, NGOs, and others have done at fostering real demand. These insights would be essential in the design of programs.

- *Potential response of the private sector.* Bringing the private sector into the agriculture sector in a big way will be an important part of the government's strategy, but little is really known about the private sector's perception of the risks and rewards, and what they see as an essential framework of policies, incentives, and opportunities that would facilitate their entry.

Annex A.

Regional Cooperation in the Zambezi River Basin

A.1 SADC AND THE ZAMBEZI PROCESS

The importance of improved water resources management and increased water utilization in fostering economic growth, alleviating poverty, and reducing food insecurity has long been recognized among the states of the southern African community. In the mid-1980s, UNEP played a catalytic role in bringing the Zambezi riparian countries together to launch an action plan for the integrated development of the water resources of the Zambezi River basin.⁵⁸ The plan, called ZACPLAN, consisted of 19 projects called ZACPRO.

Meanwhile, a number of important international water conferences were held in the early 1990s, including the International Conference on Water and Environment in Dublin (1992) and the United Nations Conference on Environment and Development, Rio de Janeiro (1992). These conferences served to foster global attention and consensus on the core principals that should guide sustainable water resource development.

ZACPRO 2 and the SADC watercourse protocol. Within the ZACPLAN framework, SADC led and facilitated a process within the southern African community under the ZACPRO 2 project to translate the core principals, as set out in Agenda 21, into a framework for water resource development within the region. The result of this process was the adoption of a Protocol on Shared Watercourse Systems by the member states in 1995.⁵⁹ Article 2 of the protocol adopts the principle that member states lying within a shared watercourse system will maintain a proper balance between resource development for a higher standard of living for their people and conservation and protection and enhancement of the environment to promote sustainable development. Among other principles, the member states committed to cooperation in regard

to the study and execution of projects likely to have an effect on the regime of the watercourse system, to share data and information, to utilize shared watercourse systems in an equitable manner, and to take into account in their utilization of shared watercourse systems all relevant factors including the effects of the use in one watercourse state on another watercourse state.

Article 3 commits the member states to establish appropriate institutions necessary for the effective implementation of the protocol, including River Basin Commissions between basin states and in respect of each drainage basin. These new river basin management institutions were intended (article 4) to develop a monitoring policy for shared watercourse systems, to promote the equitable utilization of shared watercourse systems, and to monitor the execution of integrated water resource development plans.

Despite this forward looking agreement, SADC and the member states recognized that there were important constraints to its full implementation. In 1998, the member states adopted a Regional Strategic Action Plan (RSAP) for IWRM in the SADC countries (1998). This plan was intended to develop within the region and the member states the enabling environment for the implementation of IWRM and the protocol. As such, it did not focus on “hard” infrastructure, but instead on seven key areas where progress was needed: legal and regulatory frameworks; policy formulation; management information systems; human and institutional capacity building and awareness raising; and expanded stakeholder participation. Much of the RSAP program is still ongoing.

ZACPRO 6. The aim of ZACPRO 6 was to develop an integrated water resources management plan for the ZRB. The first phase was contracted to the Zambezi River Authority (ZRA),⁶⁰ who with support from Danish International Development

Agency (DANIDA) implemented the program through Danish consultants. To initiate the first phase, ZACPRO 6.1.1, a common database, ZACBASE, was established. The basin was divided into an agreed set of sub-basins for analytical purposes, and an initial hydrologic model developed to support the planning process. ZACPRO 6.1.2 focused on a series of sector studies encompassing: water consumption and effluents in rural and urban areas including industry and in the agriculture sector including fisheries and livestock; patterns of land use and conservation practices in the basin; environment, tourism, and wildlife; hydroelectric power generation; utilization of waterways for navigation; and the environmental impact of basin development. The studies sought to document existing conditions within the basin and to prepare projections for the future based on a range of scenarios that would constitute a basis for developing a basin development strategy and plan.

The need for joint management of Zambezi waters.

The water resources in the ZRB that remain to be developed are substantial in relation to the likely increase in water consumption in each of the riparian countries over the next 20 years. Each country in the basin has its own expectations and plans for additional development of Zambezi basin water resources for irrigation, hydroelectric power, drinking water, and industry as well as other uses, and their individual requirements for in-stream flow and wetland and biodiversity conservation, including water quality management. The development of surface- and groundwater for these purposes is essential to the economic and social development priorities of the riparian countries.

There are strong economic and social interests along the main stem of the Zambezi River represented by the major hydroelectric generating facilities located there. Environmental flow requirements for such in-stream uses as fisheries, wetland conservation, and water quality management—which typically extend across watershed and catchment⁶¹ as well as country boundaries—will grow in importance with population and economic growth. Joint management and development of the Zambezi's resources will, therefore, be of growing importance to avoid development constraints and needless costs and conflict.

Although there appears to be sufficient water resources available to support substantial new development in different sectors, neither water

demand or water availability are distributed evenly in time or space. Well before aggregate resource limits are reached at basin scale, limits will likely appear in different sub-basins or catchments, either because of local constraints within the sub-basin or within smaller catchments of the sub-basin, or because of the interplay of these local requirements with regional water demands developed by downstream or upstream riparians within the Zambezi basin.⁶² As these limits are approached, the countries will face increasingly complex regional and subregional water management challenges.

The Zambezi Process. The complexity of the problems and great scope for water resources development in the ZRB made it a natural focus of SADC efforts to implement the protocol and RSAP through a new regional watercourse institution for the Zambezi basin, specifically a watercourse commission referred to as ZAMCOM. This process of collaboration among the Zambezi riparian countries, with support and facilitation from SADC, and which really began in the late 1980s, is known as the Zambezi Process.

Recognizing that sustainable development of ZRB water resources in any one country of the basin would require joint management of Zambezi basin waters among all the basin countries, SADC has worked intensively with the riparian countries and within the framework of the SADC watercourse protocol, to develop a framework that would enable joint management and accelerated development. As early as 1998, a draft ZAMCOM agreement was developed, but negotiations stalled because of concern that the draft agreement would constitute a de facto allocation of water before key countries were in a position to evaluate its consequences in light of their development needs and aspirations.⁶³ The process was restarted under phase II of ZACPRO 6 and culminated in the signing of a ZAMCOM agreement by seven of the eight Zambezi countries (Zambia is still considering the agreement) in July 2004.

The countries' intention is for ZAMCOM to promote the equitable and reasonable utilization of the water resources of the ZRB, as well as the efficient management and sustainable development of these resources. A technical steering committee has been established by the riparians and work has already begun within the framework of this committee to agree on the modalities for implementa-

tion of the agreement including the details of the location, responsibilities, functions, and the organizational setup of the commission. The countries expect that the launching of ZAMCOM will enable them individually and jointly to shift the focus to development and implementation and to mobilize the financial resources required.

A.2 THE NEPAD INITIATIVE

Overlaying the rising demand for water resources development within the Zambezi riparian countries, and the movement toward integrated and joint management of the water resources of the ZRB, is the New Partnership for Africa's Development (NEPAD). It was launched in October 2001 as an Africa-led initiative of the African Union for self-sustaining economic development. Agriculture was the only economic sector included in the first NEPAD Action Programme, in the belief that this sector is not only crucial for addressing hunger, poverty, and inequality, but also fundamental for overall African economic growth. In June 2002, the African heads of state and government approved a Comprehensive Africa Agriculture Development Programme (CAADP) as a framework for the restoration of agriculture growth, food security, and rural development in Africa.

CAADP is an integrated framework of development priorities that focuses on investments in five mutually reinforcing pillars, the first of which is "Expansion of the area under sustainable land management and reliable water control systems." As a

first step toward implementation of CAADP, the NEPAD Secretariat has formulated action programs and initiatives for each of the CAADP pillars. The program to improve management of water resources and expand access to irrigation (small and large scale) would include four activities:

1. Investment in better management of river basin water resources
2. Investment in strategic public infrastructure for water control, creating the opportunity for private sector investment in irrigation
3. Investment in small-scale water management including rainwater harvesting and drip irrigation
4. Establishment of partnerships with farmer organizations and local administrations to manage access to and use of farm land

Implementation of this action plan involves the collaborative preparation of National Medium-Term Investment Programs (NMTIPs) and associated Bankable Investment Project Profiles (BIPPs). The NEPAD Secretariat has asked the FAO to work with each country that requests that NMTIPs and BIPPs, as well as other regional and international partners, to prepare these key documents. All eight countries of the Zambezi basin have requested this assistance. All the NMTIPs are in progress. The initial drafting of BIPPs is also in progress in seven of the eight countries. The priorities that are concerned with water resources and irrigation indicated in the draft NMTIPs are summarized in table A-1 along with known cost estimates.⁶⁴

Table A-1 NEPAD–CAADP Project Priorities for Irrigation Development in the Zambezi Basin

| Country | NMTIP priority water project or program | BIPP available | Estimated cost (million US\$) |
|------------|---|-------------------------------------|-------------------------------|
| Angola | Irrigation Rehabilitation and Sustainable Water Resource Management | <input type="checkbox"/> | |
| Malawi | Inputs Development Project (includes irrigation) | <input type="checkbox"/> | |
| Mozambique | Small-Scale Irrigation Project II | <input checked="" type="checkbox"/> | 22.4 |
| Mozambique | Small Dam Rehabilitation and Construction | <input checked="" type="checkbox"/> | 30.0 |
| Namibia | Harnessing Water Resources for Irrigation and Livestock | <input type="checkbox"/> | |
| Tanzania | District Irrigation Schemes | <input type="checkbox"/> | |
| Zambia | Nega-Nega Irrigation Scheme | <input checked="" type="checkbox"/> | 11.2 |
| Zimbabwe | Smallholder Irrigation Development | <input checked="" type="checkbox"/> | 67.0 |
| Zimbabwe | Rehabilitation of Smallholder Irrigation Schemes | <input checked="" type="checkbox"/> | 90.7 |

Source: NEPAD-FAO NMTIP & BIPP Reports.

Although the CAADP is somewhat broader in purpose and scope than this study, the NMTIPs and BIPPs have been utilized as an important source of insight into the sector and an expression of country priorities.

A.3 WORLD BANK GROUP AFRICA ACTION PLAN

In response to the challenges of poverty reduction and economic growth in Africa, the World Bank has recently prepared⁶⁵ an Africa Action Plan (AAP) that provides a results-oriented framework to support critical policy and public actions led by African countries to achieve well-defined goals, including the Millennium Development Goals (MDGs). Sub-Saharan Africa's long-term, slow growth is due to both low investment efficiency and low investment levels. Since 1995, the fastest growing economies have benefited from higher investment rates and were able to generate higher returns on investment.

The AAP would support among other things the "drivers of growth," one of which is making agriculture more productive and sustainable. In line with NEPAD's CAADP, the World Bank's strategy for African agriculture is based on two pillars: first, lending and advice to address domestic barriers to higher productivity; and second, analysis and advocacy at the international level to dismantle obstacles to agriculture production and exports. The Bank's strategy includes: (i) increased physical investment in agriculture, especially irrigation, water resources management, rural roads and infrastructure, and research and extension; (ii) elimination of policy discrimination against rural goods, and increasing service delivery for rural areas in agriculture and other sectors (for example, education and health); (iii) higher productivity through the use of more sustainable agriculture practices; (iv) strengthened natural resource management; and (v) scaled-up support to farmers and agribusiness through improved market access, supply chain for development, and rural finance.

Annex B. The Zambezi River Basin

The geology, hydrology, land capability, and present development patterns of the Zambezi River basin suggest a convenient division of the basin into three parts:

- The *Upper Basin* that includes all the drainage area above Victoria Falls⁶⁶ and includes sub-basins 1-08 to 1-13 in figure B-1. The maps in this annex are taken from the ZACPRO 6 final reports by DENCONSULT (1998) and Niras Consultancy (2003).
- The *Middle Basin* that includes the Kafue, Luangwa, Kariba (the Gwembe Valley catchments including Gwati, Sengwa, and Sanyati river basins in Zimbabwe), and the small,

unmeasured Mupata River sub-basins (sub-basins 1-04 to 1-07).

- The *Lower Basin* that extends from the head of the Cahora Bassa Reservoir to the Indian Ocean (sub-basins 1-01 to 1-03) and includes the Shire River–Lake Malawi sub-basin.

B.1 UPPER ZAMBEZI RIVER BASIN

The Upper Basin includes portions of Angola, Namibia, Botswana, and Zambia, and constitutes a major part of the headwaters of the Zambezi. The other portions are in the Kafue (1-07), Luangwa (1-05), and Shire River–Lake Malawi (1-03) river basins.

Figure B-1 Zambezi River Basin



The Upper Basin encompasses about 38 percent of the area of the Zambezi basin, and produces the largest contribution to average annual ZRB outflow, 37.9 km³, or about 39 percent of the total outflow.

Important features of the Upper Basin include:

- The population density in the Angola, Namibia, and Botswana portions of the Upper Basin are extremely low (less than 2/km²), and very low in the much larger Zambian portion of the basin, except for the concentration of people on the fertile soils along the flood plains, dambos, and at the margins of the Kalahari sands in the Barotse sub-basin (1-09).
- In general, rural infrastructure and access to markets is very poor throughout the Upper Basin. A number of small run-of-river hydroelectric facilities, totaling about 28 MW, have been identified in the Upper Basin that could help to improve electricity access and possibly stimulate additional irrigation development and improve drinking water supply.
- Seventy-four percent of the area of the Upper Basin comprises wetlands, swamps, and protected areas (33 percent), and land that is steep, covered with Kalahari sands, or soils derived from these sands that are seasonally waterlogged (41 percent). A large part of the Upper Basin is covered by a deep blanket of

wind-blown Kalahari sand, which severely limits agricultural production, although these sands are often well covered with economically important hardwoods.

- Pressure is high on the limited fertile land in the Zambian portion of the Upper Basin (an estimated 66 percent of arable land was currently cropped) but extremely low in the Angola portion of the basin (about 2 percent) as well as the Namibia and Botswana portions of the basin. However, a large part of the potential for increased agricultural land use (rainfed or irrigated) in the Upper Basin is in Angola, about half of the best arable land in the Upper basin is located in Angola.

The outflow from the Upper Basin passes over Victoria Falls (and through the run-of-river hydropower power plants installed there) and directly through the Zambezi gorge into Lake Kariba. The hydrograph of mean monthly runoff from the ZRB above Kariba gorge is shown in figure B-2.⁶⁷ Both the shape and timing of the hydrograph derive mainly from the outflow of the Upper Basin. Changes in land and water use in the Upper Basin that would result in significant changes in the seasonal volume and timing of flows from the Upper Basin are, therefore, potentially sensitive.

Figure B-2 Hydrograph of Mean Monthly Runoff from the Zambezi Catchment above Kariba Gorge, 1907–98, Showing Runoff Contribution from the Upper Zambezi Catchment (Mororwe) and Gwembe Valley Catchment (Gumbora)

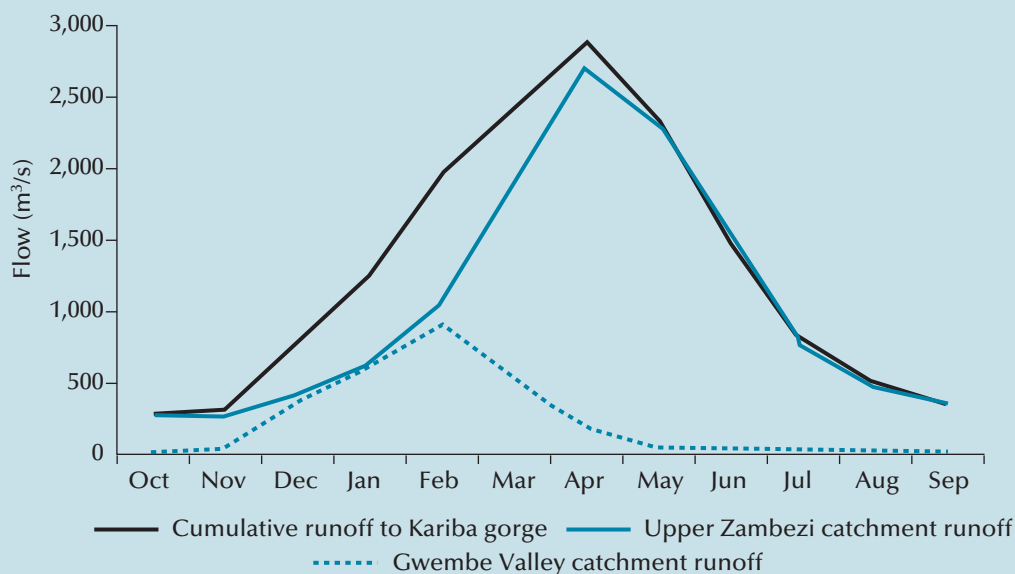


Table B-1 summarizes key land and water use data estimated by ZACPRO 6 for the Upper Basin. Forty percent of the land currently cropped was located in the Barotse sub-basin (1-09) and 63 percent of the total was located in Zambia. Seventy-two percent of the irrigation water use in 1995 was located in the Cuando/Chobe (1-08) and Barotse (1-09) sub-basins.

ZACPRO 6 made a rough projection of the most likely extent of irrigation development in each sub-basin and country in the Upper Basin. The projected total increase in irrigation water use between 1995 and 2015 was about 242 Mm³, about 0.6 percent of the total outflow of the Upper Basin. Most of this increase would stem from the possible development of a large sugarcane estate (>10,000 ha) in southern Angola. Otherwise, ZACPRO 6 did not foresee large increases in irrigated area in the medium term in the Upper Basin. Apart from the possible large sugar estates in southern Angola, the study projected a doubling of irrigation water use in the Upper Basin (from a very small base), mainly by concentrating on the development of small surface- and groundwater schemes, particularly where smallholder areas are subject to high rainfall variability.

B.2 MIDDLE ZAMBEZI RIVER BASIN

The Middle Basin extends downstream from the terminus of the Upper Basin above Victoria Falls to the confluence of the Luangwa and Zambezi rivers above Cahora Bassa Reservoir. The Middle Basin is shared primarily by Zambia and Zimbabwe, with a very small area in Botswana and Mozambique. It includes the Kafue River basin (1-07) that is entirely in Zambia (figure B-1), the Kariba sub-basin (1-06) that is shared between Zambia and Zimbabwe (with a very small area in Botswana), the Luangwa River sub-basin (1-05) that is almost entirely in Zambia (a very small area in Mozambique), and the small Mupata sub-basin (1-04) that lies between the Kafue and Luangwa and is shared by Zambia and Zimbabwe.

About two-thirds of the Middle Basin represents one of the most productive areas of the Zambezi basin (figure B-1). The middle Kafue sub-basin, the northwestern and western Luangwe sub-basin, and the Zimbabwe portion of the Kariba sub-basin have good soils and reliable rainfall. Agricultural systems in this area range from sub-

Table B-1 Upper Zambezi Basin Land and Water Use

| | |
|---------------------------------------|-------------------------|
| Total area | 519,200 km ² |
| Cultivable area | 5,150,00 ha |
| Current cropped area (1995) | 280,000 ha |
| Current irrigated area (1995) | 4,710 ha |
| Current irrigation water use (1995) | 33,100 Ml/yr |
| Projected irrigation water use (2015) | 274,820 Ml/yr |

Source: DENCONSULT 1998; NIRAS Consultancy 2003.

sistence through emergent commercial-to-commercial, including private large-scale commercial and corporate estates. Proximity to urban areas and good communications have stimulated emergent commercial-and-commercial farm development. The remaining area of the Middle Basin, including the lower Kafue, most of the Luangwe, the Zambian portion of the Kariba sub-basin, and the Mupata sub-basin are devoted to wildlife conservation, cattle and game ranching, and forest preserves because of poor soils, high temperatures, and low, erratic rainfall. Water harvesting using small check and storage dams, contour bunds, and other measures are important means of assisting small subsistence farmers in these areas.

The hydrology of the Kafue is quite complex (figure B-3). The Lukanga Swamp in the Upper Basin significantly attenuates the inflow to the Itezhi-Tezhi Reservoir—which controls about 70 percent of the Kafue drainage area—shifting the flood peak about two months later than peak rainfall. Itezhi-Tezhi Dam was designed to provide flow regulation for the Kafue gorge hydroelectric power plant (HEP) whose reservoir is very small. The inflow and outflow hydrographs of the Itezhi-Tezhi reservoir are shown in figure B-3. However, between Itezhi-Tezhi and Kafue Gorge, the Kafue flats wetland provides additional regulation, the effect of which can be seen in figure B-3.⁶⁸ The substantial time shift in peak flow and increase in dry season flow caused by operation of the Itezhi-Tezhi reservoir—and by flooding and surface storage in Kafue Flats—is also illustrated in figure B-3.

The net gain in Zambezi River flow as it traverses the Middle Basin is 28.5 km³, 29 percent of the total outflow of the river to the ocean. The Kafue and Luangwa river sub-basins, which join the Zambezi River downstream of Kariba Dam, contribute about 88 percent of the outflow of the Middle Basin. The

net flow in the Middle Basin is reduced by two important factors: first, evaporation from Lake Kariba (8.9 km³), and second, ET from the wetlands and swamps in the middle and lower reaches of the Kafue (Lukanga Swamp and Kafue flats) and Luangwa rivers as well as evaporation from reservoirs (for example, at Kafue gorge and Itezhi–Tezhi). It should be noted that these wetland areas encompass important wildlife conservation and protected areas with high tourism value.

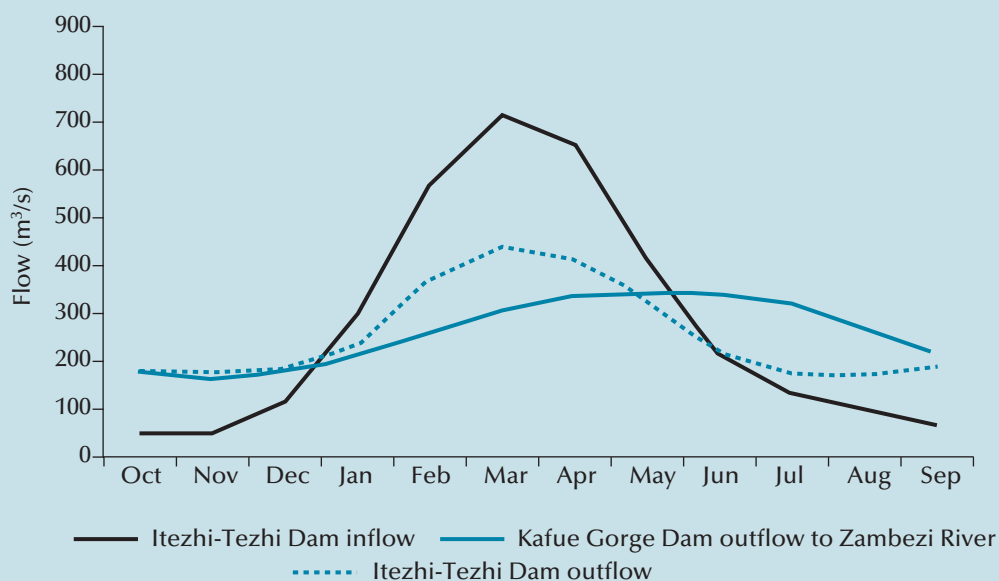
There are nine HEPs in the Middle Basin including Kafue gorge (900 MW), Kariba North and South (1,266 MW), three small plants on the Luangwe totaling 50 MW, and three plants at Victoria Falls totaling 108 MW. All are associated with storage reservoirs except Victoria Falls, which is run-of-river (ROR). The Itezhi–Tezhi Dam and Reservoir upstream of Kafue gorge provides additional regulation capacity for the Kafue gorge HEP. The Kariba Reservoir on the Zambezi is one of the largest man-made lakes in the world, and is designed to regulate the highly variable inflow from the Upper Basin and a small contribution from the Kariba sub-basin.⁶⁹

Table B-2 summarizes key land and water use data estimated by ZACPRO 6 for the Middle Basin. The largest fraction of cropped area is located in the Kariba sub-basin in Zimbabwe (46 percent), with nearly all the balance in Zambia in the Kafue (24

percent) and Luangwa (29 percent). However, ZACPRO 6 projected that growth in irrigation water use by 2015 would be concentrated in the Kariba and Kafue sub-basins (88 percent of total incremental water use for irrigation). It should be noted that competition for water from industry, domestic drinking water, irrigation, hydropower generation, wetland and biodiversity conservation, and environmental flows is probably greater in the Kafue River sub-basin than in any other sub-basin of the Zambezi. This is clearly likely to intensify in the future to become a very great challenge for Zambian water management authorities.

Additional hydropower capacity for internal consumption and/or export is a priority for both of the Middle Basin countries, Zambia and Zimbabwe. Eleven new HEPs have been proposed for the Middle Basin to add 5,810 MW. Excluding the ROR plant at Victoria Falls, the addition of HEP generating capacity at Kafue gorge and at Itezhi–Tezhi Reservoir on the Kafue, and the addition of Kariba North and South (since these would not result in a change in reservoir surface area), the estimated annual evaporation loss at the five remaining proposed storage and HEP projects would be an estimated 14,493.4 Mm³—nearly equal to the evaporation from all existing reservoirs. However, it should be noted that 90 percent of this incremental loss would stem from just two of the proposed

Figure B-3 Hydrographs of Mean Monthly Runoff from the Kafue Catchment above and below the Itezhi-Tezhi Reservoir and Runoff below the Kafue Gorge Dam (1977–98)



projects: Mupata Gorge and Katombora, both on the Zambezi River.

B.3 LOWER ZAMBEZI RIVER BASIN

The Lower Basin extends from the confluence of the Zambezi and Luangwa rivers at the head of the Cahora Bassa Reservoir to the Indian Ocean. It consists of two parts: the great East Africa Rift Valley system occupied by Lake Malawi and the Shire River (sub-basin 1-03); and the intersecting lower Zambezi River valley (sub-basin 1-02). Sub-basin 1-01 extends from the point where the Shire River joins the Zambezi River a short distance downstream of Sena in Mozambique to the Indian Ocean. The delta begins further downstream near Mopeia, about 120 km from the ocean.

The entrance to the Lower Zambezi Valley and the Lower Basin is through the Cahora Bassa gorge. Figure B-4 is the hydrograph of mean monthly discharges at the Cahora Bassa Gorge before and after the Cahora Bassa Reservoir was completed.

The gain in total cumulative flow of the Zambezi River across the Lower Basin is about 31 km³ or about 32 percent of the total outflow of the ZRB as a whole. The Lake Malawi–Shire River sub-basin is the single largest contributor to the outflow of the Zambezi River (exceeding even the Upper Zambezi

Table B-2 Middle Zambezi Basin Land and Water Use

| | |
|---------------------------------------|-------------------------|
| Total area | 480,200 km ² |
| Cultivable area | 6,590,000 ha |
| Current cropped area (1995) | 1,542,976 ha |
| Current irrigated area (1995) | 65,361 ha |
| Current irrigation water use (1995) | 558,997 ML/yr. |
| Projected irrigation water use (2015) | 682,475 ML/yr. |

Source: DENCONSULT 1998; NIRAS Consultancy 2003.

sub-basin 1-13). The huge Cahora Bassa Dam and Reservoir are located at the head of the Lower Basin and provide a very high degree of regulation of flows coming from the Middle Basin.⁷⁰

Table B-3 summarizes key land and water use data estimated by ZACPRO 6 for the Lower Basin. The Lower Basin is much more intensely utilized than either the Middle or Upper Basins. Grain crops, mainly maize, accounted for 70 percent of the cultivated area. Sixty percent of this cultivated area is located in Malawi in the Shire River valley (Shire–Lake Malawi sub-basin, 1-03), 25 percent in Zimbabwe (Tete sub-basin, 1-02), and the balance (14 percent) in Mozambique, with about 1 percent in Tanzania.

As in the Middle Basin, there is substantial water infrastructure in the Lower Basin for hydro-

Figure B-4 Hydrographs of the Mean Monthly Runoff at Cahora Bassa Gorge before and after Completion of the Cahora Bassa Reservoir

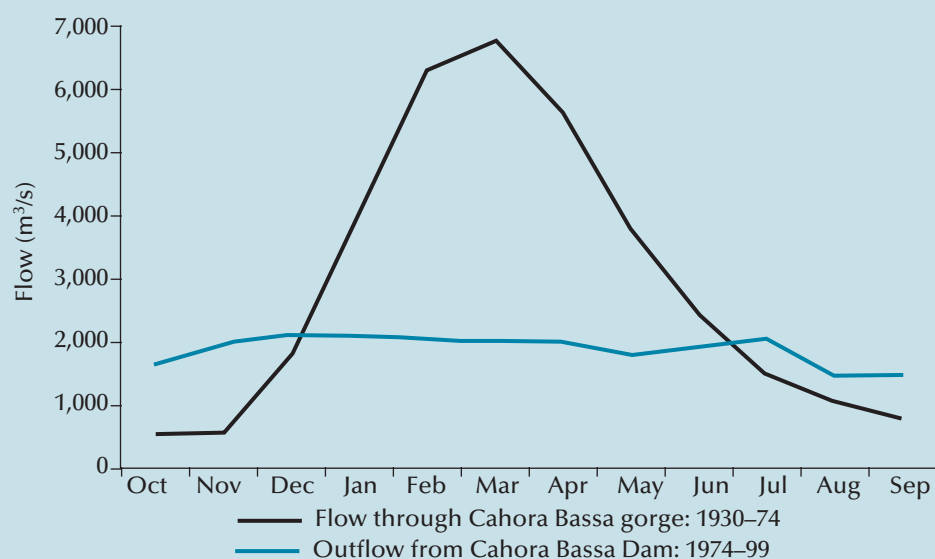


Table B-3 Lower Zambezi Basin Land and Water Use

| | |
|---------------------------------------|-------------------------|
| Total area | 372,600 km ² |
| Cultivable area | 8,590,000 ha |
| Current cropped area (1995) | 2,966,094 ha |
| Current irrigated area (1995) | 101,480 ha |
| Current irrigation water use (1995) | 886,153 Ml/yr |
| Projected irrigation water use (2015) | 1,234,300 Ml/yr |

Source: DENCONSULT 1998; NIRAS Consultancy 2003.

electric power. These include five ROR plants on the Shire River totaling 280 MW, one small plant on the Wovwe River (5 MW), and Cahora Bassa (2,075 MW). A large number of new HEPs have been identified and several studied, including both ROR and storage projects.

Proposals in the Tete sub-basin (1-02) include an additional powerhouse at Cahora Bassa (1,200 MW), a new large ROR project immediately downstream, Mepanda Uncua (2,000 MW), which would utilize the upstream regulation at Cahora Bassa, as well as 10 other proposals totaling 3,596 MW.

Proposals in the Shire–Lake Malawi sub-basin (1-03) also include ROR and storage (S) projects. The Shire River benefits from regulation from Lake Malawi, so the additional capacity added there would be ROR. Elsewhere, HEPs are proposed for the Rukuru/Rumphu (ROR), Songwe (S), Ruhuhu (ROR), and Rumakali (S) rivers, totaling about 580 MW.

The estimated open water evaporation from existing reservoirs in the Lower Basin is 5,805.9 Mm³. Open water evaporation associated with the proposed new HEP projects summarized above would increase evaporation by an estimated 5,146.9 Mm³. However, 54 percent of this increase would occur at the Chemba project (3,600 MW) on the Zambezi River, which is not thought to be an early candidate for development.

B.4 COMPARISON OF THE ZACPRO 6 STREAMFLOW ESTIMATES WITH MORE RECENT STUDIES

Table B-4 summarizes the estimates of average annual streamflow at the outlet of the key sub-basins of the ZRB and compares the estimates developed in the ZACPRO 6 sector studies in the mid-1990s with those developed by Beilfuss and dos Santos in

2001 as part of the hydrologic studies of the Zambezi delta. Figure B-5 is a plot of this comparison and shows also the relative contribution of the sub-basins to total water availability in the basin. The estimates agree quite reasonably, given the data gaps and uncertainties in the hydrologic record.

The only significant difference is in the estimate of streamflow from the Luangwa River sub-basin and the ungauged catchments that lie between the Kariba Dam and the head of the Cahora Bassa reservoir. The difference in the estimate of total streamflow through the delta to the ocean is largely explained by the estimate of flow from these Middle Basin catchments. It is not possible (and may not be important at this time) to determine which is the more reliable estimate of Middle Basin outflow, but it is noteworthy that the Beilfuss and dos Santos study includes a detailed water balance of the Cahora Bassa Reservoir. If this was also done in the ZACPRO 6 model, it was not reported.

B.5 WATER RESOURCES IN THE ZAMBEZI RIVER BASIN

The average annual rainfall over the Zambezi basin (figure B-6) is about 980 mm, ranging from a low of about 500 mm in the southern portions of the basin to a high of 1,400 mm along the northern limits of the basin. ZACPRO 6's estimate of the average total volume of annual rainfall is about 1,300 km³ (130,000 Mm³).

Rainfall and runoff. About 90 percent of annual rainfall occurs in the months of November to March, with the remaining 10 percent occurring early (September and October) or late in the rainy season in April and early May (mainly in the latter period). Peak runoff would normally occur in the months of February and early March, but in sub-basins where there are large wetland and flood plain storage areas (for example, Barotse 1-09) in the Upper Zambezi, or the Lukanga Swamp and the Kafue flats in sub-basin 1-04, peak flow is typically shifted one to two months later. Significantly attenuated and dry season base flows increased because of the slow surface drainage and groundwater recharge and subsequent discharge from these areas. The storage of water on the ground surface and the slow drainage of these natural storage areas also result in significantly increased ET and an overall reduction in runoff volume. In the ab-

Table B-4 Comparison of Estimates of Water Availability in the Zambezi River Basin

| Zambezi sub-basin | | Catchment area ^b (km ²) | ZACPRO 6 estimate ^a (km ³) | Beilfuss and dos Santos estimate ^b (km ³) |
|-------------------|--|---|---|---|
| 1 | Upper Zambezi basin | 507,200 | 37.93 | 32.9 |
| 2 | Gwembe Valley basins | 156,600 | | 7.2 |
| 3 | Total to Kafue gorge | 663,800 | 39.25 | 40.1 |
| 4 | Kafue River basin | 154,200 | 8.83 | 9 |
| 5 | Luangwa River basin (including sub-basins 1-04 and 1-05) | 163,146 | 18.34 | 28 |
| 6 | Total to Cahora Bassa gorge | 1,050,000 | 65.21 | 77.1 |
| 7 | Plateau tributaries (ZACPRO 6 sub-basin 1-02) | | 10.27 | 13 |
| 8 | Lake Malawi–Shire River basin | 154,000 | 20.14 | 17 |
| 9 | Zangue basin | 8,500 | | 0.5 |
| 10 | Total to the Zambezi delta | 1,390,000 | 97.43 | 107.6 |

a. ZACPRO 6 Phase 1.2 Sector Study, Overview Report, December 2003.

b. Beilfuss and dos Santos 2001.

sence of this natural runoff regulation, there is typically little or no streamflow in the dry season except in the principal rivers.

Long-term rainfall and runoff cycles. Historically, there is significant variation in annual and seasonal rainfall around the mean, with long cycles of low and high rainfall⁷¹ as well as spatial rainfall variation due to altitude. Comparison of dimensionless double mass curves of runoff and rainfall over the major Zambezi sub-basins⁷² suggests that long-term runoff cycles are primarily explained by rainfall cycles. Over the three decades from 1950–1980, rainfall was generally well above the long-term av-

erage, but since about 1980 there has been a sharp reduction. The effects of these last two cycles can be seen in figure B-7, which shows the mean monthly outflow from Kariba Dam.⁷³ The Kariba Reservoir has 64,798 Mm³ of live storage capacity, about 160 percent of the long-term mean annual inflow to the reservoir. Nevertheless, Kariba spilled regularly up until 1980, but has not spilled since—with the exception of 2004 at the time of the extensive flooding in the Lower Zambezi Valley.

While unit runoff tends to increase with increased rainfall, a sequence of particularly low rainfall years, such as has occurred since 1980, can significantly reduce the proportion of annual rain-

Figure B-5 Comparison of Zambezi Basin Water Availability Estimates

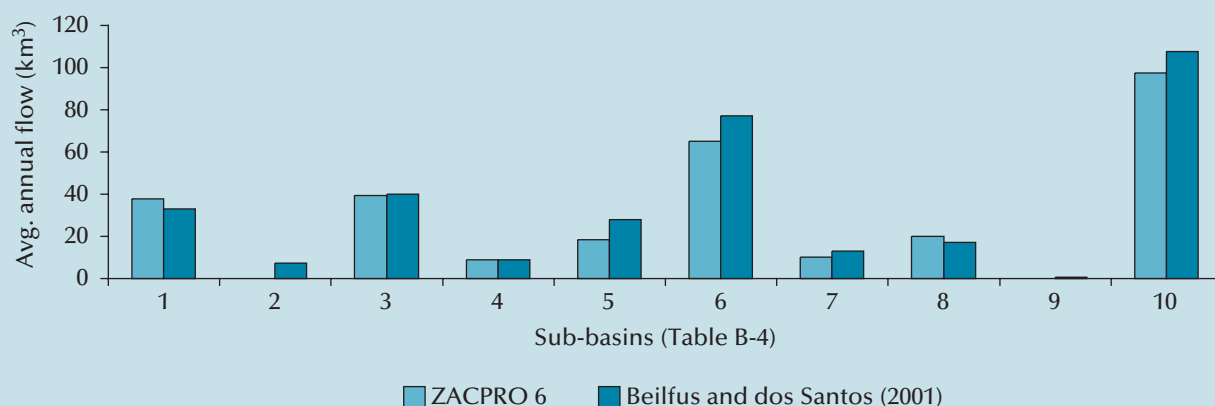


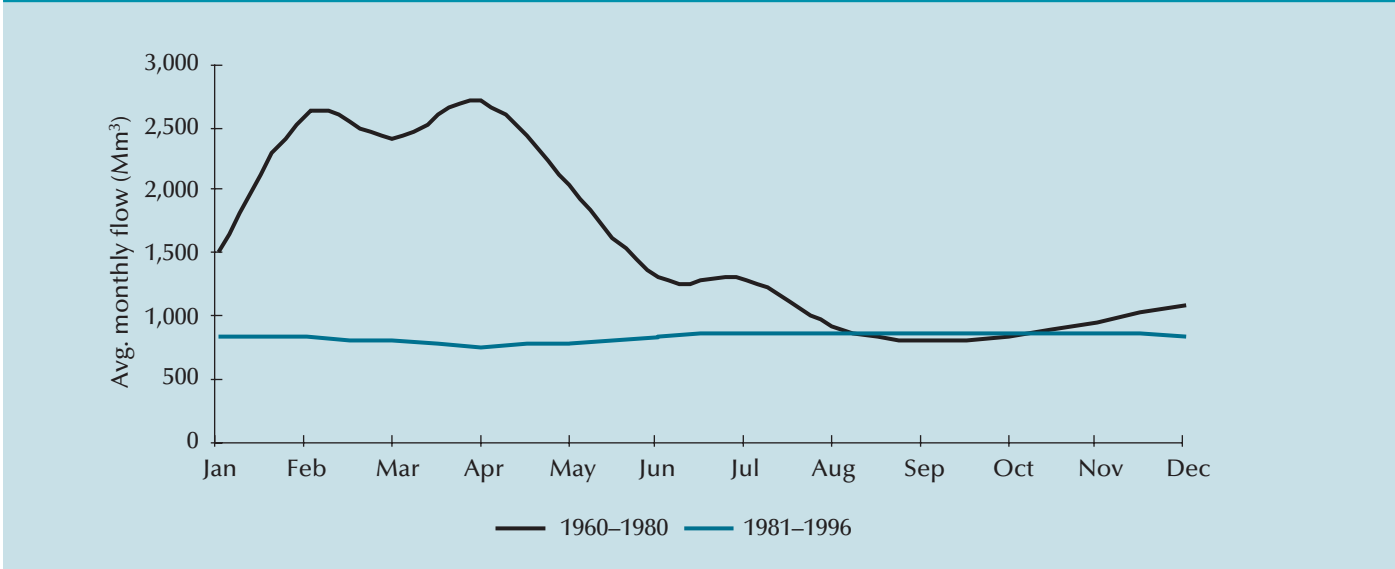
Figure B-6 Mean Annual Rainfall



fall that occurs as runoff.⁷⁴ Less evident in the records is the erratic nature of short-term, more localized rainfall patterns—low magnitude, shortened season, late onset—often experienced at lower elevations in the splinter rifts of the East Africa Rift Valley System, and in the rain shadows caused by the numerous escarpments and mountain ranges. These more localized effects significantly increase the risk experienced by rainfed farmers and traditional irrigation schemes in the dry season.

Effects of changes in land use on runoff. Beilfuss and dos Santos (2001) suggest that based on their studies of the Upper Basin, land use and land cover changes are unlikely to have had a significant effect on Zambezi River runoff patterns.⁷⁵ In response to concerns expressed by some reviewers, ZACPRO 6 Sector Study No. 3 used a basin hydrologic simulation model to examine the effects that land use changes—such as urbanization, irrigation development—would have on the hydrology of the ZRB.⁷⁶ Would trends in these sectors lead to dramatic or

Figure B-7 Average Monthly Outflow from Kariba Dam (1961–1996)



important changes in runoff or streamflow as a consequence of development? In modeling several scenarios, the study found that the effects of most changes in land use had little effect on total runoff. For example, conversion of all agriculture in the Kafue River sub-basin to irrigated agriculture would only account for a change of 6.1 percent in total runoff from the sub-basin. In a more extreme example, if all the rainfed area in the ZRB (5.2 million ha) were converted to irrigated agriculture, total runoff in the Zambezi River would change by only 3 percent. A more elaborate and upgraded simulation model needs to be developed to provide a more accurate picture of both the magnitude and distribution of streamflow throughout the year at critical water management locations throughout the basin under different water demand scenarios and for different sequences of project developments. Building such a shared DSS, with the associated analytical tools, would be a high priority task on which the new ZAMCOM secretariat and water resource management authorities in the riparian countries could collaborate.

The sub-basin and catchment perspective can be quite different. The need for DSS and these model studies may be even more important at the sub-basin or catchment level. The effects of these land use changes and water withdrawals, while not too significant in terms of runoff at the basin or sub-basin level, could be significant in terms of seasonal water availability for different purposes at the microlevel, for example, where there are environmentally sensitive areas⁷⁷ that depend significantly on the annual shape, timing, and volume of the streamflow hydrograph, as well as the magnitude of the peak flow. Wetlands would be an especially important example of this type of water requirement. Another example would be diminished dry season flow—abstraction of water from wetlands, drainage of wetlands, and increased groundwater withdrawals are examples of how this may occur—that reduces the reliability of irrigation water supplies based on dry season river flow where storage is limited, that is, there is not sufficient economic wet season storage capacity so that direct river diversion is needed to meet at least a part of the dry season irrigation demand. The combination of natural and constructed storage and protected groundwater recharge will take on greater water management importance as economic growth proceeds and land use changes.

Figure B-7 suggests that reservoir operations and power production at Kariba could be sensitive to even relatively small changes in the inflow hydrograph during a low rainfall cycle despite its enormous volume of live storage.⁷⁸ In general, the operation of the huge reservoir at Kariba, and downstream at Cahora Bassa, has had dramatic effects on the streamflow regime downstream and, consequently, on river and floodplain health, especially in the flood season. Outflows from Kariba have reduced mean monthly flow by 37 percent, 48 percent, and 46 percent in March, April, and May respectively, and reduced the extent of flood inundation downstream in the Mana Pools National Park (a World Heritage Site).⁷⁹ On the other hand, dry season flows have more than tripled, changing the character of the Zambezi River in this reach.

Cahora Bassa has had a similar effect on the lower Zambezi River, in particular, dramatically changing flood patterns in the Zambezi delta. The Kariba and Cahora Bassa experiences suggest that water managers in each of the riparian countries and in ZAMCOM must think about not only the level of water abstraction and consumption for various purposes, and the volume of storage to be developed upstream, but also the modalities of operation of the *Zambezi storage system* to ensure the health of the rivers and directly connected floodplain and wetland areas that have significant local and national economic, environmental, and social importance.⁸⁰

These issues again emphasize the importance of developing a DSS for the ZRB to study the optimal development of the basin, that is, the maximization of *total benefits*, from a holistic point of view rather than a narrow sector or project perspective, and develop alternative management and development strategies on which one could build consensus. This could also be done in the short term for the lower Zambezi sub-basin by assuming different flow regimes at the entrance to Cahora Bassa. It would remain to discuss these flow regimes with the upstream countries and interests (ZRA, for instance), but it would give Mozambique and Malawi an opportunity to study a range of strategic scenarios; evaluate tradeoffs among different objectives and development strategies, taking into account the needs and demands in all sectors; and to seek an optimum from their own perspective. The political economy of decision making in regard to the use and allocation of water resources in the

Lower Basin, and the operation of the Cahora Bassa storage and hydropower complex,⁸¹ would be much improved by this undertaking.

Importance of groundwater discharge in dry season streamflow. ZACPRO 6 simulation model studies of rainfall and runoff in the Kafue sub-basin indicated that about 30 percent of the average runoff was from groundwater discharge. Unfortunately, the lack of data and knowledge of groundwater prevented ZACPRO 6 from making an assessment that would apply to larger areas of the ZRB, but the overall hydrologic assessment indicates that in many sub-basins groundwater—besides being the major if not the only component of dry season streamflow—is likely to be an important future source of water for both domestic and industrial use and for agriculture. Hence, identifying, protecting, and enhancing recharge areas and mechanisms and protecting the quality of groundwater in the future may be important for sustainable development.

B.6 ENVIRONMENTAL ISSUES

ZACPRO 6 studies found that the environmental sensitivity of the ZRB is low based solely on changes in water consumption (figure B-8). However, when increases in population, increased point and nonpoint source pollution, more dams and reservoirs for hydropower and other purposes, are overlaid with the pattern and magnitude of

changes in water use and consumption and environmentally sensitive areas, a number of areas in the basin were identified where increased stress and vulnerability could result in significant environmental harm and loss if management interventions are not undertaken.

These areas were summarized in a map of priority environmental management areas (figure B-9). Among the most important priority areas are the Zambezi delta and estuary, which have already been adversely impacted by the major upstream reservoirs, including Cahora Bassa, and the declining flow of the Zambezi River; wetlands and biodiversity hotspots including the Barotse flood plain, the middle and lower Kafue River basins, the Maputa area, southern Lake Malawi, and the Shire River valley; and the invasion of exotic species, particularly water hyacinth in Lake Kariba. In many areas, deforestation and land degradation are already causing soil erosion and sedimentation of watercourses and rivers, the Shire River being one of the most fragile and vulnerable examples. Many of these environmentally sensitive and fragile areas are of substantial economic importance. The pressure on these areas will stem from both changes in streamflow and water quality. A strategic basin approach to determining the environmental flow requirements (EFR) for each of these areas should be undertaken before the impacts of any individual project proposals are assessed to avoid intersector conflict and possibly irreversible loss.

Figure B-8 Major Areas of Biodiversity in the Zambezi

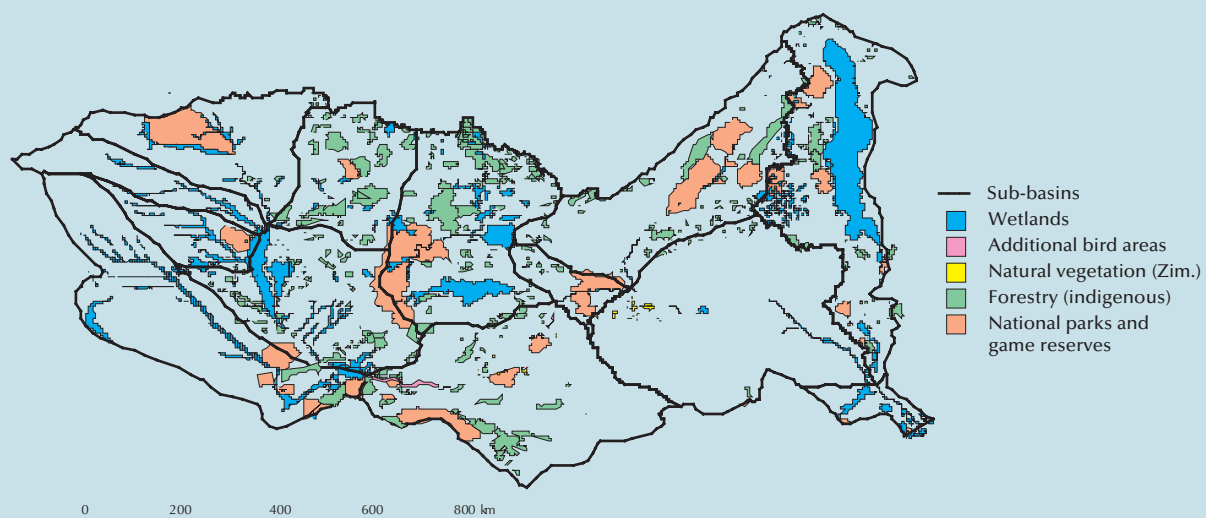


Figure B-9 Priority Environmental Management Areas, 2015



B.7 INTEGRATED WATER MANAGEMENT CHALLENGES IN THE ZAMBEZI BASIN

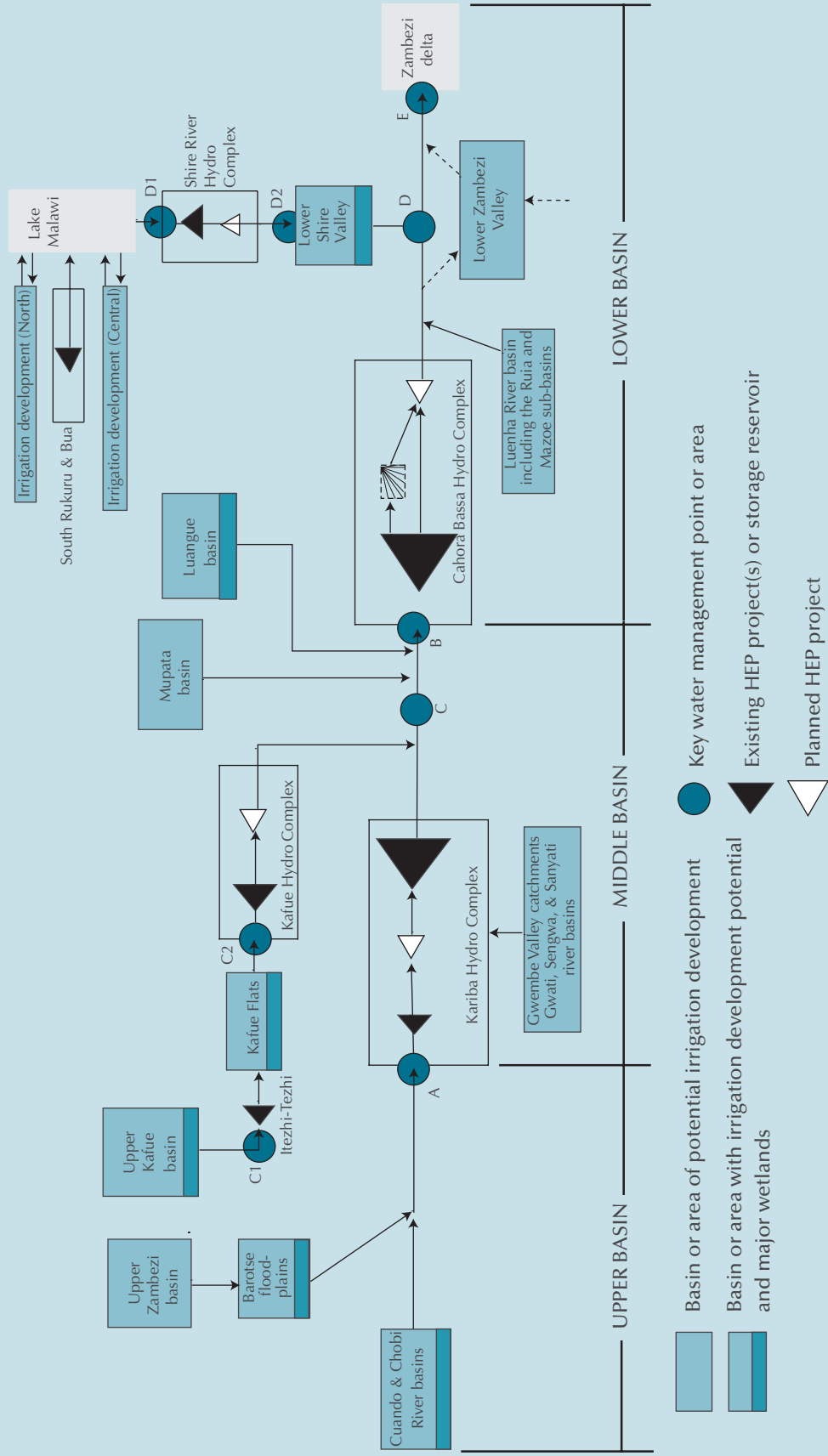
Figure B-10 is a generalized schematic diagram of the Zambezi basin that helps to illuminate in a simplified form the important spatial relationships and linkages between sub-basins, features, and potential development areas that—apart from rainfall—have the most influence on streamflow. It also identifies key locations where integrated water management challenges are most critical to sustainable development and management of the basin. These locations are where water managers at both the regional and sub-basin—generally national—levels must seek to balance upstream and downstream needs and demands for the utilization and consumption of water and the respective watercourses in a manner that achieves agreed national and regional objectives, including environmental sustainability.

Figure B-10 highlights several locations along the main stem of the Zambezi River that will be critical for sustainable water resource management, but similar critical locations can be identified within the main sub-basins, such as those shown in figure B-10 for the Kafue and Lake Malawi-Shire River basins. What makes the Zambezi basin

unique is that, with a few exceptions,⁸² the main stem of the river constitutes the principal joint watercourse, that is, the key watercourse that must be managed jointly by the riparians if they are to enjoy the full and equitable utilization of the water resources of the basin, which is the goal of the new Zambezi Watercourse Agreement. In turn, agreement on how the main stem will be managed—in terms of, say, 10-daily or monthly streamflow volume, discharge, or timing—establishes important parameters and boundary conditions for the management and utilization of the tributary rivers that are largely under national management.

Goals and objectives of joint management. The SADC Protocol on Shared Watercourse Systems (1995), agreed by all the Zambezi riparians, has provided an important framework for the process of developing the recently agreed (2004) Zambezi Watercourse Agreement. The protocol established the principal that member states within a shared watercourse system should maintain a proper balance between resource development for a higher standard of living for their people and conservation and enhancement of the environment to promote sustainable development. These goals of water and watercourse development, conservation

Figure B-10 Schematic of the Zambezi River Basin



Source: Mission estimates.

and protection of the resource, and sustainability have consistently framed the Zambezi Process, which led to the agreement on joint management of the Zambezi basin in 2004. This agreement, in addition to defining the rights and obligations of the parties, adds an important, explicit objective to ensure the equitable and reasonable utilization of the waters of the basin by the riparian states. Most importantly, the agreement establishes a process for preparing rules of application to facilitate equitable and reasonable use of the Zambezi watercourse.

The main stem of the Zambezi River. There are major economic, social, and environmental interests and values along the main stem of the river that utilize the flow of the Zambezi River directly, and there are major proposals to expand these uses. The most prominent are the two major hydroelectric complexes at Kariba (shared by Zambia and Zimbabwe) and Cahora Bassa (Mozambique). Not to be overlooked is the river itself in the reach through the Middle Basin, and the important adjoining natural areas with high environmental and economic values (the flood-prone lower Zambezi valley and the delta region). Expansion of the existing powerhouses at Kariba Dam has been proposed as well as the construction of a new dam and reservoir at Batoka Gorge upstream of Kariba below Victoria Falls.⁸³ Similarly, Mozambique is proposing an addition to the Cahora Bassa powerhouse and the construction of a new dam and reservoir downstream at Mepanda Uncua that will function as a ROR hydropower facility utilizing the upstream storage at Cahora Bassa. Hence, agreeing upon and maintaining an agreed flow pattern at *locations A and B* (figure B-10) that enables the optimal operation and production of these two complexes, and the protection and conservation of the health of the main stem and adjoining natural areas in this reach including the delta, is a decision of considerable economic importance to the basin countries that benefit directly or through the Southern Africa Power Pool (SAPP) from this electricity production.

The Middle Basin below Kariba. Managing the flow pattern at *location B* will depend on developments in both the Lower and Middle Basin below Kariba⁸⁴ since the outflow of the Kariba complex (figure B-10) is for all practical purposes nearly uniform⁸⁵ at present.

Very little development except of a local nature is foreseen for the Luangue and Mupata basins.

Large parts of the Luangue River basin are national parks and protected areas. However, the western Luangue and northern Mupata basin were shown by ZACPRO 6 as having high agricultural potential, and they form a part of the large peri-urban area of Lusaka that is a high priority for the development of high value agriculture. The Kafue River basin is the third major part of the Middle Basin below Kariba. It is a complex sub-basin with high development potential. Zambia is anxious to expand HEP facilities in the Kafue gorge and at Itzhi-Tezhi. The intervening Kafue flats is a Ramsar Site surrounded by irrigation development potential and is potentially well connected to markets in Lusaka and beyond. Upstream of Itzhi-Tezhi is a major national park, the huge Lukanga Swamp that provides flow regulation for the modest Itzhi-Tezhi reservoir (2,000 Mm³), and further upstream is the copperbelt mining areas whose drainage is a significant component of the flow of the upper Kafue River.

Rainfall in both the Kafue and Luangue varies dramatically from north to south (figure B-6), so one would expect a large number of small and medium dams to be built in the middle and lower Kafue basin to support irrigation and rural water supply where average rainfall drops below say 800 mm, further complicating the water management problem. Although the average outflow of the Luangue is about twice that of the Kafue, managing the Kafue from both a national and regional perspective will be important.

Two key water management locations are highlighted in figure B-10, *location C1* downstream of Itzhi-Tezhi and *location C2* upstream of Kafue gorge but downstream of Kafue flats. A detailed simulation model and analysis of the basin would no doubt identify other locations where management decisions on water allocation and regulation of water use will be important to the optimal development of the whole basin, but these two serve to highlight the manner in which the integrated water management challenges at the regional or Zambezi basin level are mirrored within sub-basins at the national level.

The Lower Basin. What is decided at *location B* depends not only on what is decided for *locations A and C* upstream, but also what is decided for the two downstream *locations at D and E* (figure B-10). Major developments are planned by Mozambique and Malawi that must be taken into account when

determining the water management needs and targets for *location B*. These include the additions to the Cahora Bassa hydropower complex, the development of a major coal mine and thermal power station near Tete, expansion of irrigation in the Lower Zambezi Valley by Mozambique, development of the lower Shire River valley by Malawi (*location D*) for irrigation and navigation that would extend through the delta to the Indian Ocean, and the water requirements to restore and sustain the environmentally, economically, and socially important Zambezi delta (*location E*).

The Lake Malawi–Shire River basin (*location D*)—the major feature of the lower Zambezi in addition to Cahora Bassa and the delta—presents equally complex management challenges. The lake—the third largest in Africa and the 10th largest in the world—provides an enormous volume of storage and a degree of regulation of the Shire River, its only outlet. However, the lake level is subject to long rising and falling cycles and will be influenced by the level of development that will occur in Tanzania’s Nyasa basin, and by the flow through the outlet (*location D1*), which is controlled by the lake level and the shallow depth of the outlet. This is critical because just downstream is Malawi’s most important ROR hydroelectric complex and the lower Shire River is an important source of irrigation water supply. The lower Shire also contains important wetland and wildlife areas, and the government has high hopes of establishing a reliable navigation route from the lower Shire River to the sea through the lower Zambezi River and the delta.

The Lower Zambezi Valley is an important multisector development area for Mozambique and the delta (*location E*) is a wetland and reserve of global significance⁸⁶ as well as an economically important fishery, including a large shrimp fishery. The government has plans for extensive irrigation development, mainly in the small tributary basins along the valley, and a major coal mine is being developed for export through an upgraded rail and road network connecting to the Port of Beira to the south. There are two critical water management issues in the Lower Zambezi Valley, and both are connected to the pattern and magnitude of flood flows in the Zambezi River.

The delta ecosystems (*location E*) are highly adapted to the annual flood and recession of Zambezi River water that, under natural conditions, also varies significantly from year to year.⁸⁷ Not only are the different associations of flora and

fauna adapted to these patterns, but so also are the breeding and feeding behaviors of the large number of birds, animals, and fish that inhabit this wetland system. Since the late 1950s, when Kariba was completed and commissioned, and since Cahora Bassa was commissioned in 1974, flood patterns in the delta have been dramatically affected. The duration (frequency) of floods above levels that allow the Zambezi River to spread overland and through the numerous creeks and channels has greatly diminished. Zambezi River flows now rarely exceed the minimum threshold for discharging into the upper delta waterways, and overbank flooding is mostly limited to the brackish coastal region under the influence of tides. The movement of floodwaters from the main river channel of the Zambezi to the delta flood plain is also obstructed by large dikes constructed for the roadway and railway line along the Zambezi River.

The hydrologic restoration of the delta, and the mitigation of the cumulative impacts of upstream development over the last century, will require reestablishing the natural hydrologic regime of the delta by simulating the natural hydrologic conditions, a process known as prescribed or engineered flooding. That, in turn, will require managing and harnessing the key water control infrastructure upstream as well as future water development and water use patterns upstream in a manner to support this new regime in the lower Zambezi River.

Flooding along the Zambezi River upstream of the delta has been similarly affected. However, the rapid changes in land use along the Zambezi floodplains since the completion of Cahora Bassa have led to increased flood damages and loss of life. Reports indicate that people believed that with the completion of Cahora Bassa, serious flooding would no longer occur in the Zambezi floodplains. Farms and settlements quickly began to encroach onto the floodplain. This is the area with the most fertile soil, high soil moisture, and access to water. However, although the frequency of large floods has declined, the rapidity with which flood waters can arrive has greatly increased because of the manner in which the Cahora Bassa Reservoir and its outlets works are managed. Sudden, very large discharges have occurred and arrived in settled areas so quickly that people did not have time to evacuate. The classic system of flood risk management—forecasting, warning, preparedness, and response—have not yet been developed for this area, resulting in severe economic and social consequences.

Annex C.

Policy and Institutional Framework

C.1 POLICY AND INSTITUTIONAL FRAMEWORK FOR IRRIGATION DEVELOPMENT IN MALAWI

Irrigation development in Malawi is the responsibility of the Ministry of Agriculture, Irrigation and Food Security (MOAIFS). Among its six departments are the Department of Agricultural Research and Technical Services, which includes the Department of Irrigation (DOI), and the Department of Agricultural Extension Services. The NEPAD NMTIP noted that these departments have become severely constrained due to declining funding and lack of institutional capacity, and that administrative and staff salaries absorb most of the agricultural budget leaving little for operational activities.

The government is currently implementing a decentralization policy under which authority is being transferred to local people. For a host of reasons, the implementation of this policy has been problematic within MOAIFS. Many MOAIFS staff, including DOI staff, are already present in the decentralized Agricultural Development Divisions, which, however, do not conform with district boundaries, where lies the focus of the decentralization policy. This is important because the focus of both the new irrigation policy and the decentralization policy is on the participation of local people, including farmers, in the identification and prioritization of problems, and in decision making on the use of resources and the formulation of projects and programs. Long delays in redeploying MOAIFS staff and reorienting them to the new development framework will make it difficult for the government to achieve its goals, which has important implications for the irrigation sector.

In June 2000, MOAIFS formulated a new National Irrigation Policy and Strategy. Among the key policy statements are: DOI will facilitate the development process to create an environment

in which the private sector, smallholders, estates, and commercial farms invest in irrigation development; irrigation will be promoted to increase incomes and commercialization of the sector; development of irrigation schemes will ensure the full participation of farmer beneficiaries from identification to planning, design, and implementation; an environmental impact assessment will be undertaken for all medium- and large-scale irrigation development; financing will ensure minimum government subsidies, and the principles of cost-sharing and cost-recovery will be applied.

These policy statements frame a new strategy for the development of irrigated agriculture. The strategy includes the targeting of development by identifying areas with physical potential, based on surface water and groundwater availability, agro-ecological factors, and economic analysis. The aim is to identify those areas with the best possible chance of success. A participatory approach to scheme development will be used to ensure full ownership of irrigation schemes by the beneficiaries through legally constituted local organizations that will oversee all matters related to operation and maintenance. Formation of farmer organizations will be a necessary condition for scheme development. The government will provide assistance and support to this process. Costs of rehabilitation of government schemes prior to turnover will be borne by the government. All operation, maintenance, and replacement costs are to be borne by the farmers in the irrigation schemes. Scheme financing will be designed to minimize government subsidy. The government will develop a program of cost-sharing for capital costs, in which consideration will be given to matching grants, in-kind contributions, food-for-work programs, and cost-sharing for materials, equipment, and labor.

The process for development of smallholder schemes will include an awareness program to

inform farmers of the potential that exists. Dialogue will be undertaken to identify agricultural, technical, and social problem areas of interest, as well as the interest and attitudes of beneficiaries, and community capacity and aspirations. The government would provide assistance to farmers to develop irrigation schemes.

The intention of government is to transfer ownership, management, operation, and maintenance of existing government schemes to those farmers who are currently in those schemes. Since government land can only be turned over to an organization with legal status, it will introduce legislation to enable the formation and registration of smallholder irrigation farmer groups.

Although the strategy outlines several programs and initiatives to develop the necessary capacity within DOI, the private sector, and other concerned institutions to implement this new policy, there is little evidence so far that this is being seriously done. It is doubtful that the policy and strategy is widely understood among field staff who will be at the sharp end of its implementation. New ways of thinking and behaving will be required and new skills will need to be acquired in order to implement this policy and strategy, particularly in the areas of: community mobilization; formation of viable and sustainable farmer and community groups; continuing support to such groups; and participatory planning, design, and implementation. The policy and strategy are a clear attempt to shift development efforts away from the former top-down, government supply-driven approach, which has failed in the past with few exceptions. However, it cannot be done without a dramatic change in the skills and capacity of staff, and an overall change process within DOI and its partner departments. For example, although the strategy implies that DOI is responsible for the participatory scheme development process, the department assumes that the extension service will have this role. But the extension service department has no more capacity or capability to do this than DOI.

C.2 POLICY AND INSTITUTIONAL FRAMEWORK FOR IRRIGATION DEVELOPMENT IN ZIMBABWE

During the 1990s, there was a concerted drive by the government to recast agriculture and water de-

velopment policy and strategy to revive the sector. Zimbabwe's Agriculture Policy Framework 1995–2010 (ZAPF)—launched in 1996 after extensive stakeholder consultation—established four basic pillars: (i) transformation of smallholder agriculture into a fully commercial farming system; (ii) an annual increase in agricultural output significantly larger than the annual population growth rate; (iii) development of physical and social infrastructure in all rural areas; and (iv) the development of fully sustainable farming systems throughout the country. ZAPF placed much greater reliance on market forces than in the past as well as on increased levels of private sector investment and substantial improvements in the efficiency of the use of capital. In the smallholder sector, ZAPF again emphasizes a commitment to strategies that transform the sector into a fully commercial farming system, implying that it should be self-sustaining and profitable.⁸⁸ ZAPF included among its key strategies: (i) priority would be given to farmer-managed and operated systems; (ii) effective water users associations would be encouraged and facilitated in the planning, development, and evaluation of irrigation projects; and (iii) water allocation would take into account and address the imbalances in water supply between large-scale commercial farms (LSCF) and smallholder irrigators.

The Millennium Economic Recovery Programme (MERP) issued in 2000 by the government draws heavily on ZAPF and focuses on several important measures in the irrigation sector⁸⁹ including, among others: (i) security of land tenure; (ii) promotion of effective land utilization; (iii) proper producer prices; (iv) provision of farm input support; (v) improvement of marketing; (vi) encouragement of contract farming; (vii) establishment of farmer associations; and (viii) promotion of irrigation development.

In the mid-1990s, the then Ministry of Rural Resources and Water Development established the WRMS to restructure water policy and institutional arrangements through a widely consultative process. This process resulted in a new Water Act in 1998 that made several important changes: (i) established the Zimbabwe National Water Authority (ZINWA) as a self-financed (through water charges levied on bulk water supply customers) parastatal within the ministry that would be responsible for bulk water supply development and delivery to irrigation systems, cities, towns,

industry, and other water users; (ii) changed the role of the Department of Water Development to one of policy and regulation of the sector; and (iii) changed fundamentally the system of water rights, eliminating the former doctrines of rights held in perpetuity and “first in time, first in right”, to a permit system that enabled a process of reallocation of water rights to address the changes in water demand brought about by FTLRP.

The Water Act and the WRMS shifted the focus from solely supply management to demand management, established the role of water pricing for bulk supply in the sector, and created a framework for stakeholder participation in water resource management (paralleling the increased role of stakeholder participation in irrigation planning, development, and scheme management called for under ZAPF and MERP). Under the act, ZINWA has established a system of catchment and sub-catchment councils, whose main task is to prepare an outline plan for their respective catchments (two have been completed to date). These new institutions had barely become operational when the farmer composition changed drastically from 2000 as white commercial farmers were replaced by new farmers who had not been involved in the WRMS consultation process. Hence, the operationalization of the new water catchment councils (a statutory body of basin stakeholders) has stalled and may further be delayed by the need to bring the new farmers into the process.

Within the irrigation sector itself, direction, policy, and strategy are much less clear. The DOI, within the Ministry of Agriculture and Rural Development, was formerly a unit of the Department of Agricultural Technical and Extension Service (now the Department of Agriculture Research and Extension—AREX). DOI is responsible for planning, design, construction, operation, maintenance, and monitoring and evaluation of most government-funded formal, small-scale irrigation. However, it appears that other units within AREX are also engaged in these activities, as well as the Agriculture and Rural Development Authority (ARDA)—a parastatal within the ministry that operates the government-owned estates and irrigates over 13,000 ha and serves a large number of associated smallholder out-growers. The overlapping roles and blurred boundaries might not be a serious problem if there were a single, clear irrigation policy that was coherent with both the new water policy and act, and the MERP.

C.3 POLICY AND INSTITUTIONAL FRAMEWORK FOR IRRIGATION DEVELOPMENT IN ZAMBIA

Among the major policy shifts that accompanied economic liberalization in the early 1990s was the focus on agricultural growth and other rural activities and infrastructure for poverty alleviation. Current irrigation sector policy stems directly from the PRSP (2002). The PRSP called for a sustainable and competitive agriculture sector that ensures food security and maximizes the sector’s contributions to GDP and exports. The earlier Agricultural Commercialization Program (ACP, 2001) was incorporated as the core strategy for agriculture in the PRSP. The ACP focuses on the development of infrastructure in high potential agricultural areas and the strengthening of cooperatives and farmer organizations as vehicles for achieving demand-led growth, profitable, irrigated agriculture, and a sustainable sector. The ACP emphasized the full participation of farmers in irrigation development.

Since the late 1990s, commercial smallholder irrigation has begun to emerge, principally through a variety of contract farming or out-grower schemes promoted by the private sector. Where NGOs have been mobilizing and supporting the formation of community-based groups and farmer groups, apex farmer organizations have begun to emerge to enable farmer members to access markets directly. These developments have been limited to areas with better-developed infrastructure, such as main roads and railway lines.

Zambia is also moving toward the institutionalization of integrated water resource management (IWRM). Since 2003, a new water resources management (WRM) bill has been under preparation and discussion, and is now before Parliament. The WRM bill is intended to provide a new institutional and legal framework for WRM that is consistent with the government’s decentralization policy. The bill will: establish a new National Water Resources Management Authority; establish catchment and subcatchment bodies and recognize the role of water users associations; establish a water tariff system to ensure the sustainability of the new institutional setup; and revise the water rights and permitting system. The bill provides for a five-year transition period during which existing government agencies will shift their roles, and new capac-

ity will be developed to begin full implementation of the roles, functions, and responsibilities established by the bill.

C.4 POLICY AND INSTITUTIONAL FRAMEWORK FOR WATER STORAGE AND IRRIGATION DEVELOPMENT IN MOZAMBIQUE

Responsibility for water resources and irrigation development are divided between two ministries: the Ministry of Public Works and Housing and its National Directorate of Water Affairs (Direccao Nacional de Aguas, DNA); and the Ministry of Agriculture and Rural Development and its National Directorate for Agriculture Hydraulics (Direccao Nacional de Hidraulica Agricola, DNHA).

Water resources development and management. DNA's functions include water policy, planning, provision of water supply and sanitation services, and maintenance of the data networks and information base for the sector. DNA is responsible for identifying, planning, design, construction, and operation of multipurpose water resource infrastructure including dams as well as infrastructure for water supply provision.⁹⁰ Under the 1995 water policy and the current Water Law, DNA responsibilities for integrated water resources development and management has been decentralized to five Regional Water Administrations (ARAs), each responsible for a group of river basins. Two ARAs have been established (South and Center) and a third is about to be established for the Zambezi basin. DNA has drafted a new and updated water policy that will soon be presented to the cabinet. Only minor revisions to the Water Law will be required and these will be submitted to Parliament when the policy is adopted.

The ARAs are autonomous bodies within MOPH. The government's aim is for each ARA to be an autonomous, self-sustaining water resource management organization to: provide quality water services to its clients and all economic and social sectors; participate in environmental conservation and protection; and contribute to national economic development. The ARAs' main responsibilities include planning and allocation of water resources; control (monitoring) of water use, effluent discharges and other activities affecting water resources; granting of water use rights and imposition of related fees; design, construction, and operation of hydraulic structures; provision of technical services to public and private sector water users; and collection and management of hydrologic data.

The ARAs' main source of revenue is the sale of raw or bulk water. However, current tariffs are too low for them to be self-sufficient in terms of operation and management, or to invest in new infrastructure with which they could increase sales. It has taken a long time for ARA-South, the first to be established in 1993, to convince customers that they should have to pay for water, including farmers, rural and urban water users, and the electric utility. Present tariffs are 40 Mt for agricultural users and 70 Mt for urban water supply.⁹¹ A major study to support tariff revision is currently underway, and ARA expects to establish new tariffs to at least cover its full O&M budget. How it will finance new infrastructure—even where there is already demand for new bulk water supplies from Maputo City, EDM, and large commercial farms—is a major and critical question that also needs to be studied.

Irrigation development. DNHA is responsible for irrigation development in Mozambique. It works in collaboration with the other concerned directorates of MADER including the Extensions Services Directorate and the National Directorate for Rural Development.

Annex D.

Alternative Approaches to Promoting the Growth of Irrigated Agriculture

If one at least broadly agrees with the argument outlined in the previous chapters 5 and 6, the challenge is to develop a new model or approach to smallholder irrigation improvement and development that incorporates this new policy framework, addresses the key factors that affect profitability and sustainability, integrates water resource management, and can be scaled up as capacity and skills are developed and demonstration effects spur demand.

D.1 PARTICIPATORY SCHEME IMPROVEMENT

A conceptual model for participatory scheme rehabilitation and development. Figure D-1 is a schematic diagram that broadly depicts the essential features of such a model and the associated process of smallholder scheme development. This model draws heavily on Tanzania's experience under the World Bank's RBMSSIP based on the project completion reports of both the Bank and the government. It is quite similar to the approach taken in the recently approved World Bank Irrigation, Rural Livelihoods, and Agricultural Development Project in Malawi. These projects were designed and adapted on the basis of extensive consultation on the experience of other donors in these countries and the region as well as the Bank's experience globally in other developing countries. It reflects the elements and principles found in irrigation sector policy throughout the Zambezi basin.

At the center of the diagram is the irrigator organization (IO) or water user association (WUA) that is the focal point for scheme planning, design, operation, and maintenance. In some cases, this IO may already exist when the scheme is selected (although it may or may not be registered under the appropriate legislation), or it may be necessary

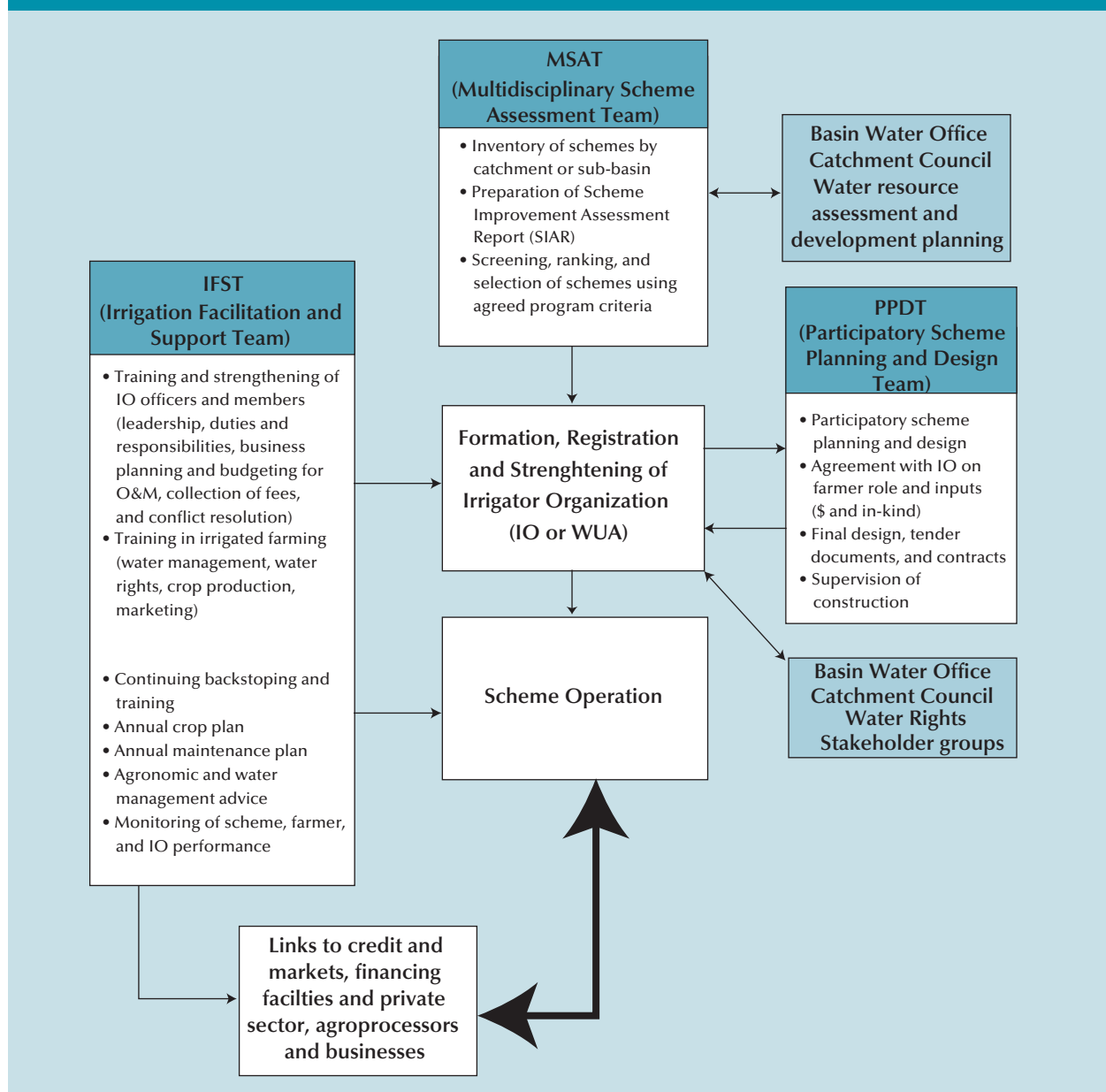
to mobilize and assist the farmers to form and register a new organization. The IO will own and operate the scheme and be responsible for its operation and maintenance (O&M), for assessing, collecting, and expending fees for O&M, scheme improvement, bulk water charges, and for conflict resolution.

At first glance, the model looks institutionally top heavy, with as many as four different teams or offices involved in the process. But in fact, these teams and offices are built from existing central- and district-level offices (especially where decentralization is an ongoing or well-advanced process) supplemented as needed with consultants, NGOs, or other organizations. Each has particular functions in the process that are briefly described below. In general, implementing this model involves a stepwise process, so that all of these teams are not involved with the IO or farmer groups at the same time.

Multidisciplinary Scheme Assessment Team (MSAT)—MSAT is the lead team in the process. It is responsible for promoting and assessing demand, evaluating the viability of proposed schemes, and for building the investment portfolio in a catchment or sub-basin. It will be evident that MSAT must complete or have available to it an up-to-date water resource assessment for catchment or sub-basin, and, hence, that it must collaborate with the basin authority to ensure that there is enough water for all the scheme proposals, and that water rights can be secured by each of the candidate schemes. Its three critical functions include:

- Inventory of schemes within a catchment or sub-basin, creating awareness among the farmers, and identifying where real demand exists in the sense that farmers express a strong desire to organize and participate in the program.

Figure D-1 Smallholder Scheme Rehabilitation and Development Model and Process



- Preparation of a Scheme Improvement Assessment Report (SIAR). Each potential scheme undergoes a multidisciplinary technical, economic, financial, and environmental assessment. Each SIAR identifies key demographic, technical, agricultural, and social data concerning the scheme itself; reviews technical options to identify the most cost-effective technical interventions to achieve the farmers' objectives and a preliminary estimate of cost; reviews possible cropping patterns with the farmers; determines

water demand and assesses that demand in the context of the basin water assessment; assesses market potential and constraints to ensure that these cropping patterns are possible and required inputs are likely to be available; presents a preliminary financial and economic analysis of the scheme using data collected from the farmers and appropriate standard data including parametric investment costs; and reviews the environmental and social assessment check-list with the farmers.

- Based on the SIAR, the MSAT reviews the agreed scheme selection criteria and recommends whether the scheme should be selected and development should begin.

The scheme selection criteria are quite important. The design of the eligibility criteria must be practical and reflect the conditions on the ground, but they must also ensure that the investment program is successful in terms of its development objectives (not in terms of its construction outputs). A typical set of criteria for selecting schemes is outlined in figure D-2²².

Irrigator Facilitation and Support Team (IFST)—This team is very important for the sustainability and performance of the scheme, and has several broad functions: (i) to engage the new or existing farmer groups, support their formation, and registration, and initiate and carry out their training aimed at developing their cohesion and skill and transforming the group into a functional IO or WUA capable of operating, maintaining, and managing their scheme; (ii) to provide continuing backstopping and support the IO or WUA after the scheme is completed including additional training focused on the management and use of water, maintenance planning and execution, and imparting the knowl-

edge required to raise the productivity of the scheme, and monitoring scheme, farmer, and IO performance, and proactively intervening with support to overcome constraints and bottlenecks. Such a team is best located in the field as close as possible to the IOs that it is supporting, which is why it is referred to in figure D-1 as a “District” team since that appears to be a common focal point in the region for decentralization; (iii) assist the IO or WUA in preparing an annual detailed cropping plan that serves as a guide to the farmers and helps them to utilize the best available agronomic knowledge to maximize production, and an annual maintenance plan that would help the IO or WUA to prepare its budget on which the O&M fee is based, and to plan and carry out the work; and (iv), facilitate a working relationship between the IO and the relevant basin authority or office to secure the required water rights and to participate in the system of catchment and basin stakeholder councils established by the basin authority.

Figure D-1 also shows that IFST has an important facilitating and catalytic role in linking farmer members of the IO or WUA to market value chain. The aim in this regard would be to promote the new potential of the scheme, to foster contacts between the IOs within its jurisdiction and the pri-

Figure D-2 Typical Scheme Selection Criteria

- Irrigation is demanded by the beneficiary farmers, a large portion of whom are among the program’s target groups (for example, smallholders)
- Beneficiaries are willing to form an IO or WUA prior to scheme rehabilitation or development and are willing to actively participate in all phases of planning, design, and construction with their own resources
- Scheme development is initiated in response to WUA request and their formal commitments for participation and contribution as well as future operation, maintenance and management of the scheme
- Proposed schemes should be socially, technically, financially, and economically sound as documented in the SIAR
- Specific criteria might include:
 - Modality of irrigation (certain modes of irrigation such as sprinklers or pumps might be excluded)
 - The proposed approach is least-cost, and can be readily maintained by the IO or WUA
 - There might be a minimum and/or maximum size
 - There might be a requirement for a minimum water supply reliability or minimum dry season water supply (say, to irrigate at least 50% of the area); the capital cost to be invested in the scheme might be limited to say, US\$2,000/ha (what is included in this cost is specified)
 - Recurrent or O&M costs might be limited to a maximum amount or a maximum percentage of the expected financial returns to the farmer under quite conservative assumptions
 - No disputes outstanding on water rights, land rights, or rights-of-way or easements for construction of facilities (that is, entirely voluntary land acquisition)
 - No unacceptable environmental or social impacts for which a “negative list” might be specified
 - Access to markets for inputs and production can be readily demonstrated

vate sector ranging from dealers in inputs to outgrower and other agribusiness opportunities.

Participatory Scheme Planning and Design Team (PPDT)—The intention is for a single team to carry through the process from scheme planning to supervision and completion of construction in collaboration with the IO or WUA. This is the crucial step in which specific technologies are selected with the IO and costs are controlled.

Detailed guidelines for participatory irrigation management. The process and approach depicted in figure D-1 is clearly an outline intended to show the major steps in the process and the relationship among the various participants. There are a great many details that would need to be worked out in terms of process, procedure, and substance. What is typically done in this case is to prepare a Guideline for Participatory Irrigation Development and Management in which these details are given. There are many examples of this type of detailed guideline, but each is highly adapted to the social, institutional, and physical context of the particular country and program.

D.2 IMPLEMENTATION AND FINANCING

Alternative institutional arrangements to implement this process. There are a variety of arrangements through which this process could be implemented. Traditionally, government irrigation departments would lead and staff these teams with seconded team members or support from other concerned departments, such as extension services. However, no country in the region appears to have at present the capacity to staff this program on an accelerated or scaled-up basis, nor would they be allowed to staff up to do so because of the budget implications. The core roles of government in this process are two: first, to establish policy and coordinate, monitor, and supervise policy and program implementation; and second, to provide essential long-term expertise at the “district” level. Here we have used the term “district” as a surrogate for the level to which each government is implementing its decentralization program. This second role links both irrigators and rainfed farmers to the research system and best available agronomic and water management

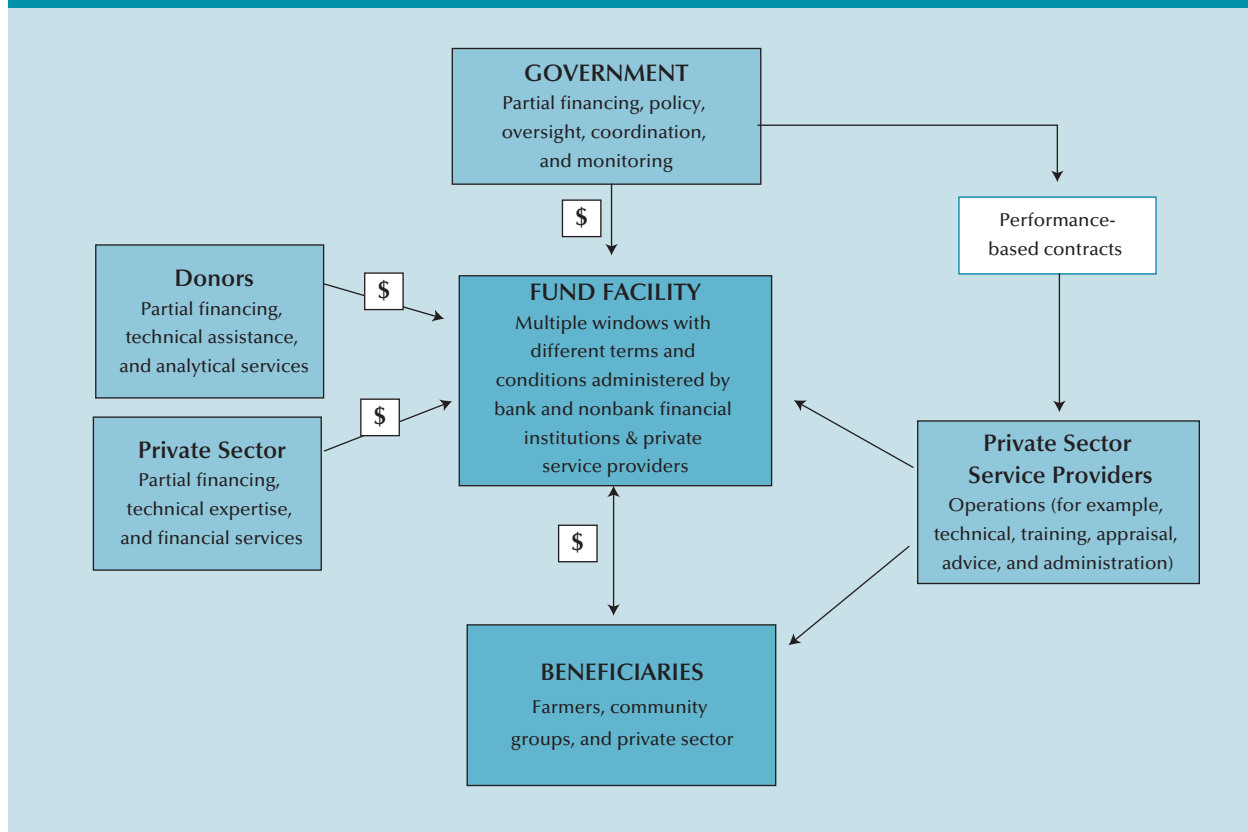
knowledge, and provides a local focal point through which continuing training and support services can be provided to IOs and WUAs. In any case, both the center- and the district-level bodies would of necessity be small and highly trained.

In this approach, the teams identified in figure D-1 (MSAT, IFST, and the PPDT) would be outsourced to service providers selected by competitive bidding. Private sector or NGO entities would be engaged to provide these services using performance-based contracting methods. Because the aim is to scale up investment, production, and farmer income, the contracts would be based on achieving minimum targets within the target river basins or catchments, with compensation rising for achievements beyond these targets based on increased coverage above the target, and *measured success* of those investments. A single provider could provide the services of one or more teams, but the three teams together would implement the program in one or more selected target basins. This approach of outsourcing program services to the private sector is an important opportunity to expressly tailor the organization and staffing of government units at the center and local levels to implement important core functions, and to focus training and capacity building in a way that enhances success and addresses long-term strategic issues.

D.3 FINANCING MECHANISMS

As the examples from both Namibia and Zambia discussed below suggest, the most efficient financing mechanism would be a special fund or facility operated through private financial institutions (PFIs)—bank or nonbank institutions. The approach, outlined in figure D-3, would help to ensure that the program remains demand-driven, and does not creep steadily toward traditional bureaucratic, government supply-driven approaches. The approach would greatly expand the capacity to absorb higher levels of financing, improve project selection and appraisal, and introduce commercial-oriented discipline on subproject sponsors.

Coordination and day-to-day management of the facility could be contracted to a private sector entity while oversight and policy guidance would be provided by a national program coordinating committee (NPCC) with the lead department as the secretariat of the NPCC.

Figure D-3 Water for Agriculture Financing Model

D.4 AN ENTIRELY COMMERCIAL APPROACH: NAMIBIA'S GREEN SCHEME

In the paragraphs below, we outline two new initiatives that are inherently demand driven and commercially oriented, but which also incorporate important socioeconomic development objectives aimed at smallholders and the rural poor. They focus on establishing targeted financing mechanisms that give an incentive for private initiative to invest in commercial agriculture and improvements in smallholder productivity and profitability. The approaches outlined are highly complementary to the participatory irrigation improvement program described above, and suggest ways that countries can broaden and enrich their comprehensive agriculture sector irrigation and rainfed development strategies and programs.

Only a very small area of the ZRB lies in Namibia. The upper Zambezi River and the Chobi River flow through the eastern end of the Caprivi Strip before joining downstream in Zambia and

Botswana. Apart from the Orange River, which forms the southern border of Namibia and is shared with South Africa, all of the other perennial rivers of Namibia are found in the extreme northern region of the country that consists largely of communal lands in which the primary land use and livelihood is livestock. The largest concentration of population in Namibia is also found in these northern communal areas, and the northern rivers are all shared with its neighbors Angola, Zambia, and Botswana.⁹³ An important challenge for the Namibia government is to seize the opportunity to utilize its share of these substantial water resources as an engine of economic and social development within this limited and generally impoverished area. The government concluded after much study that most of the past efforts in southern Africa to develop economically and financially sustainable small-scale irrigated farming—especially in cases where resettlement of inexperienced farmers and socioeconomic development were important objectives—had failed and that it must try a new approach to avoid what

it saw as the inevitable dependency of these farmers on long-term government support.

Namibia's new approach is called the Green Scheme. This scheme seeks to strike a balance between the objective of resettlement of smallholders and landless poor and their socioeconomic development needs and the objective of putting all irrigation on a sound and sustainable, fully commercial footing. It does so by promoting a partnership between private investors in commercial agriculture and a specifically recruited and trained group of small-scale farmers who themselves are committed to operating their 3 ha farms on a fully commercial basis. The government will provide a favorable legal and policy framework and provide direct support with appropriate investments and time-bound subsidies. The premise appears to be that if irrigated agriculture begins on a sound commercial footing, with good infrastructure and technology, then it will be able to adapt and respond to markets and remain sustainable.

Having identified an area (which could be a formerly government-managed scheme or a new area), a source of water supply, and the infrastructure required to bring water to the farmgate (a gravity or pump diversion and pipeline⁹⁴), the Green Scheme Coordinating Commission has opened a tender to all investors interested in developing the scheme on commercial terms, and invited applications from interested small-scale farmers and other candidates for resettlement into the scheme.⁹⁵ The selected private investor and the small-scale farmers would be granted a registered leasehold deed for their farming units by the Land Board Office in the context of the Communal Land Reform Act.

The government will impose important but limited service and development conditions on the commercial irrigation farming enterprise. In return, it will offer suitable incentives in the form of controlled access to environmental, infrastructure, and financial resources, and facilities. All financing, including the government's infrastructure investments, will be handled through the government-owned Agricultural Bank of Namibia (Agribank)—except for financing brought by the private investor. The commercial operator would be obliged to mentor and facilitate capacity building and skills development to the small-scale irrigation farmers associated with the commercial enterprise (the aggregate area of small-scale farming is about equal to the size of the commercial enterprise), and the provision of agricultural support services

(inputs, water, marketing and distribution, and so forth) on a cost-recovery basis (at cost without a risk premium). Crops and cropping patterns on the part of the small-scale farmers are not dictated by the commercial enterprise. The small-scale operators are expected to operate their units on a commercial basis and are free to adjust their activities according to their knowledge and perception of the market except that they may only engage in agromonic activities. The government is also establishing a major training facility that will provide initial six-month resident training to the small-scale farmers before the scheme becomes fully operational.

Apart from the initial training provided to the small-scale farmers who will partner with the commercial enterprise, the government would provide access to development incentives and loan collateral to facilitate the noncommercial implications of the social development objectives of the Green Scheme. The magnitude and extent of these incentives will depend on the joint—commercial enterprise and small-scale farmers—business plan, but may include financing of preinvestment studies, contributions toward the financing of all off-farm infrastructure costs (water and electricity supply), water tariff incentives for a restricted time, interest rate incentives for different types of financing needs, restricted loan guarantees and provision of collateral and, in the case of extremely capital-intensive proposals, the financing of a portion of the on-farm land development costs.

In general, the government will finance the costs of infrastructure to provide bulk water supply to the farmgate with agreed water tariffs to be paid by the farmers, but all on-farm development costs and production costs are the responsibility of the commercial enterprise and the small-scale farmers in the context of the subsidy regime (as outlined in the previous paragraph) finally negotiated with the government.

Overall, the policy aims to develop about 27,000 ha of irrigated commercial farming (about 75 percent of the remaining irrigation potential of 35,700 ha) over 15 years at a total cost to the government of about N\$3.8 billion (about US\$603 million at current rates of exchange). Although this appears to be expensive, at about US\$22,340/ha, the Green Scheme commission estimates that the government's net income from the scheme will become positive in year 9 and that over the next 30 years the estimated economic rate of return would be about 11.5 percent. The government's costs include

infrastructure to bring water to the farmgate, and provision of predetermined interest rate incentives and loan collaterals on long-term, medium-term, and bridging finance requirements of farmers. Cropping patterns in the early schemes in operation are dominated by maize and wheat because of the current favorable guaranteed prices, but higher value and export horticulture crops are already appearing at the margins of farming units. Schemes are expected to evolve toward higher value, export crops and import substitution crops where farmers have a comparative advantage.

D.5 FINANCING IMPROVEMENTS IN THE SMALLHOLDER VALUE CHAIN

Zambia's draft national irrigation plan⁹⁶ focuses on two primary constraints to the accelerated expansion of irrigated agriculture: the lack of finance and investment, and the limited capacity and effectiveness of government institutions responsible for water rights, regulation, and other sector functions and operations. It proposes to establish a fund called the Irrigation Development Fund (IDF) that would provide financing to overcome the institutional and capacity problems in the sector, and provide financing for farmers to acquire technology. The IDF would serve peri-urban and out-grower farmers, smallholders, large-scale commercial farmers, and manufacturers of irrigation equipment by financing irrigation technology packages including tools and equipment such as pumps, sprinklers, drips, and pipes, as well as larger-scale public infrastructure where it is essential. The different types of farmer groups would access the IDF through financial intermediaries including commercial banks and micro-finance institutions, providing a subsidy as appropriate directly to the financial institution for approved transactions. It would therefore be inherently demand driven.

The new World Bank project in Zambia's agriculture sector,⁹⁷ which is at an advanced stage of preparation, would go one step further by providing funds to support improvements in smallholder productivity and income and improve links between producers and markets. It would, in effect, increase smallholder commercialization in Zambia by focusing on improving the functioning and competitiveness of the value chain. It would address the key binding constraints for agrobusiness to develop competitive supply chains and to expand market opportunities for smallholders

by increasing the access to credit, and providing targeted business support and improvements to infrastructure, particularly feeder roads in areas with a high concentration of smallholders linked to out-grower and contract farming schemes. The project, in addition to institutional development, would support three key activities:

1. A *Supply Chain Credit Facility* to provide a *line of credit on a demand-driven basis* including short-, medium-, and long-term loans to finance investments that aim to improve the supply chains of existing and emerging contract farming systems. The facility would enable agroenterprises, traders, and commercial farms working with smallholders to finance capital investments, seasonal inputs, and export activities. Funds are channeled through PFIs under the supervision of an apex organization.
2. A *Marketing Improvement and Innovation Facility (MIIF)* to provide financial resources on a *matching grant basis* for the development of innovative business linkages between smallholders and other actors in the supply chain, introduce innovative technologies, and demonstrate improvements to a broader audience of supply networks. The MIIF would support studies and trials—business development, market analysis, preparation of legal frameworks, standardization and certification procedures, and so forth—extension and technology development activities, and support to capacity building to organized producer organizations. Producer organizations that market smallholder produce, and agroenterprises, traders, input providers, and nucleus commercial farms could access MIIF. MIIF would be administered by a secretariat established through competitive bidding—either a private sector entity or NGO.
3. A *Feeder Roads Improvement Facility* for the improvement of feeder roads of economic importance to agriculture through the Roads Development Authority.

Note that the project focuses on each element of the smallholder supply chain (both inputs and marketing of production) as well as the creation of nontraditional financing mechanisms that are strictly demand driven, commercially based, and are nonbureaucratically administered and managed. The government's oversight of all operations will be carried out through a national project steering committee.

Annex E. The Scope of Program Investments

The key principles that unite the government and the donors at this point are empowerment of small-holder farmers and their effective participation in the development process, building up the capacity of government organizations to implement sector policy and their new role, allowing demand to drive investment, and finding ways to overcome bottlenecks and constraints in the provision and availability of critical services. In this context, the World Bank's strategy would reflect four strategic thrusts.

Investment in water for agriculture. The Bank would invest in a wide range of water management infrastructure and technologies, including new infrastructure and rehabilitation of existing infrastructure to improve affordable and timely access to water and the technologies to manage water. This would not only include infrastructure for formal irrigation schemes—storage reservoirs, weirs, canals, and other structures—but low-cost technology for small farmer and community groups (for example, small pumps and diversion structures), and water harvesting and conservation practices and infrastructure (small check dams, contour bunds and trenches, revegetation and soil conservation, and so forth) that would enable rainfed farmers to better manage water to improve their productivity and crop production. Each scheme would be demand driven, specifically requested by farmers or community groups, who understand the responsibilities and have demonstrated their commitment. Investment would be planned, scaled, and designed with the full participation of the farmer or community group, and to match the agricultural potential—that is, economic and financial returns meet agreed criteria—and the likelihood of realistic estimates of the financial returns or profitability of the farmers that would enable them to adopt suitable cropping patterns and sustain effective O&M of the facilities.

Mobilization and empowerment of farmer organizations. Demand-led expansion of irrigated agriculture is perhaps the single greatest change to be made in the way the “irrigation business” is conducted in the region. However, the government does not have a passive role in this change. It cannot sit back and wait for demand to materialize even though policy and institutional measures that improve farmers access to financial services will no doubt go some way in this regard. As facilitator and catalyst of this development, government needs to be proactive by creating broad awareness of the potential and what is required, by mobilizing and motivating farmer and community groups, by ensuring these new or existing groups have the capacity to participate in the planning and design process and to take over management of the scheme, and by sustaining their training and capacity development over the longer term. Recent experience in the region suggests that government alone cannot do this. It will have to act through a number of different partners including NGOs, farmer associations, and the private sector. The World Bank will provide support for this process including the development and testing of new modalities for undertaking these functions, and support the necessary partnerships.

Creating financing mechanisms that enhance access to markets and financial services. Once this strategy looks beyond increasing the productivity of rainfed farmers and their production of staple food crops, the scale and nature of investment in water for agriculture will be dictated by how well farmers are linked to markets and whether they have access to financial services to, among other things, invest in new cash crops. In reviewing case studies of underutilized government schemes, one is immediately struck by the possibility that utilization is a direct function of access to markets.

How much land and water in the scheme are used depends on how much production can be sold in nearby markets, especially where access to larger and more distant markets is limited by poor roads or lack of linkages with the private sector players with market access. As was noted in chapter 3, without access to markets and financial services, the profitability of irrigation diminishes to and beyond the point where even modest investment in irrigation is viable. The World Bank would provide support for new financing mechanisms that stimulate private investment to expand out-grower and contract farming, to improve and expand agrobusiness networks and activities, and measures to enhance and expand the role of farmer and producer groups, and to expand marketing and financial services to farmer organizations.

Technology, the knowledge base, and planning. The World Bank would support the expansion and revitalization of agricultural research and development in the region that is aimed at improving water management, including water harvesting and water conservation technologies and practices. The aim would be to develop, adapt, and test technologies suitable for smallholder farmers and farmer

and community organizations in the region. An important dimension of empowerment is access to knowledge and information that allows farmers to effectively participate in the development process and to make good decisions. Reliable data and information are essential not only to the effective functioning of farmer and community organizations but also to government and private enterprises that have the potential to invest and participate in the sector. The Bank would support the improved collection, analysis, and dissemination of data and information not only through traditional government channels but also in partnership with private technology and information suppliers. Successful joint management of Zambezi basin water resources opens the door to full implementation of the basin countries' development plans. Hence, the World Bank would support, if requested, the establishment and effective functioning of ZAMCOM. The Bank would also support the strengthening of the planning function within river basin and catchment authorities to enable them to manage resources, especially to protect and secure water rights, target programs and investment, and enhance the implementation of regulatory functions.

CHAPTER 1

- 1 See annex A for a more complete description of the Zambezi Process.
- 2 Including all of the Zambezi River riparian countries. Subsequently modified and revised in 2000.
- 3 The mission to Angola has been delayed.
- 4 The exception might be the floods in Mozambique in 2001 that have served to greatly increase recognition of the importance of finding ways to jointly manage and mitigate flood risk.
- 5 The Zambezi delta is one of the shrinking number of habitat and breeding sites for the threatened Wattled Crane.

CHAPTER 2

- 6 A more detailed discussion of the three major sub-basins of the ZRB is attached as annex B. Mozambique pointed out to the mission that the shape and size of the Zambezi delta as shown in figure 2-1—taken from Niras Consultancy (2003)—is not correct. There does not seem to be agreement on the actual boundaries of the delta, but the hydrologic boundaries appear to be considerably broader than those suggested in figure 2-1.
- 7 The maps in this chapter and in annex B are taken from the ZACPRO 6 final reports by DENCONSULT (1998) and Niras Consultancy (2003).
- 8 The data in figures 2-3, 2-4, 2-5, and 2-6 are based on FAO AQUASTAT (2005) <http://www.fao.org/nr/water/aquastat/main/index.stm>.
- 9 These data are for 2003 as reported in World Development Indicators (World Bank 2004) with the exception of Zimbabwe for which the data are reported for 2002.
- 10 Niras Consultancy (2003). Although specific data are not dated in the ZACPRO 6 reports, these data likely represent conditions in the mid- to late-1990s.
- 11 Niras Consultancy (2003) (Overview of the Sector Studies under ZACPLAN).
- 12 $1 \text{ km}^3 = 1 \text{ billion m}^3 = 1,000 \text{ Mm}^3 = 1,000 \text{ gigaliters (Gl)} = 1 \text{ million megaliters (Ml)}$.
- 13 ZACPRO 6 assumed the ET from 1 ha of irrigated land to be about 8–10,000 m³/ha (8–10 Ml/ha) including an allowance for nonbeneficial ET. This would be the net consumption of water on a hectare of irrigated land. One commonly finds planning figures between 12,000–15,000 m³/ha in various project planning studies and reports in the region, but this is a gross water requirement. Since water losses in the form of surface runoff or seepage that would recharge the local shallow aquifer would be available for other uses, the ZACPRO 6 figure is the correct one to use in this type of water resource assessment. The implicit assumption in using these planning

figures is that irrigation efficiencies would lie somewhere in the range of 30 percent to 50 percent.

- 14 The main exception is the collection of rivers that form the upper basin, in particular the upper Zambezi, Cuando-Chobi, Luangwa, and Lungue Bungo rivers that are shared by Angola, Namibia, Botswana, and Zambia. A smaller instance is the extreme lower Shire River that flows for a short distance through Mozambique before it joins the lower Zambezi River.
- 15 The feasibility of undertaking joint management and investment projects would likely depend to a significant degree on the capacity and credibility of ZAMCOM in terms of technical, environmental, financial, and economic analysis, and its ability to build fair consensus.

CHAPTER 3

- 16 The data in this section are mission estimates based on data from ZACPRO 6 (DENCONSULT 1998), FAO AQUASTAT (<http://www.fao.org/nr/water/aquastat/main/index.stm>) and FAOSTAT (2005) (<http://faostat.fao.org/default.aspx>), World Bank World Development Indicators (WDI 2005), and World Resources Institute's Earthtrends (WRI 2005) (<http://earthtrends.wri.org/>), as well as data compiled from World Bank Country Economic Memorandums (CEMs) and other studies and reports.
- 17 FAO AQUASTAT (2005) [<http://www.fao.org/nr/water/aquastat/main/index.stm>].
- 18 Turpie et al. (1999).
- 19 In the FAO studies on which this section is based in part, the Zambezi countries—including Botswana, Malawi, Mozambique, Zambia, Zimbabwe, and Namibia—are included in the southern region of sub-Saharan Africa. Angola is included in the central region, and Tanzania in the eastern region. The southern region also includes Lesotho and Swaziland.
- 20 Westlake and Riddell (2005) and Bruinsma (2003).
- 21 Given more recent trends, crops grown for biofuel production may emerge in a significant way to alter these trends. The water use and water allocation aspects of large-scale commercial production of these crops that are being proposed should be investigated.
- 22 The study did not have a GIS of the basin or a working model of the basin. These tools would be essential for a more detailed and realistic estimate. With such tools, one would be able to integrate water use not only across sectors and sub-basins but also incorporate more detailed hydrologic data, the economics of irrigation and other sector uses, as well as physical, social, and environmental constraints. Developing such a DSS, with the associated modeling tools, is a critical next step in the Zambezi Process (see annex A).

- 23 This value is based on the minimum cereal utilization given in the 2004 FAO/World Food Program (WFP) Crop and Food Supply Assessment for Zimbabwe. One might argue for a higher value for 2020 because of economic and income growth, but such growth generally also leads to a diversification of diet with less reliance on cereals for calories.
- 24 Projected from the 1995 ZACPRO 6 estimate of 171,000 ha at 1 percent annual growth.
- 25 This conclusion assumes that time distribution of available and accessible water resources (the seasonal quantity of rainfall, streamflow, or groundwater) is sufficient (either naturally or by means of regulation with storage reservoirs) and accessible where it is needed, an assumption that must to be tested with the tools available in a ZRB DSS (see section 2.5)
- 26 World Bank (June 2005).
- 27 Surface water pollution is already a serious problem in the most densely populated and urbanized parts of the country, making it imperative to preserve good quality groundwater in these areas for domestic and industrial supply, and important to protect groundwater quality and the recharge areas.
- 28 World Bank (October 2005).

CHAPTER 4

- 29 This is not an argument about whether foodgrain self-sufficiency is a legitimate policy goal for the sector. The rising price of imported oil and other commodities suggests that the opportunity cost of importing staple foods (and some key industrial crops) that could be grown with the ample natural resources available and with reasonable economic returns and significant poverty impact may be significant and rising and that increased investment to close such a gap and increase industrial crop production deserves greater attention from economic policy makers than it would appear to be receiving at present.
- 30 These include Mozambique's National Irrigation Development Master Plan (Sogreah 1993), Malawi's Small-Scale Irrigation Development Study (GIBB Ltd. 2003), Zambia's National Water Resources Master Plan (Yachiyo Engineering Co. 1995), Tanzania's National Irrigation Master Plan (2002) and Action Plan (Nippon Koei 2003), Namibia's National Water Resources Management Review (2000) and Namibia's Green Scheme (2003), and Botswana's National Master Plan for Agricultural Development (2000). Donors have also undertaken in-depth investigations as a part of investment project preparation, of which the program preparation studies undertaken by IFAD consultants and staff for the Smallholder Irrigation Support Programme in Zimbabwe (1999) is a good and valuable example.
- 31 The 28 small-scale schemes identified and studied were bundled into five "projects" for financing and implementation. Unfortunately, the study reports provide only limited data for the eight schemes in Project 1 on which this remark is based.
- 32 In one case in Zambia, use of the reservoir by farmers for irrigation declined while at the same time use by fisherfolk became so intense, and presumably profitable, that irrigation use became highly restricted and conflict within the community was quite intense.
- 33 Note that both of the higher cost schemes—\$5,418/ha and \$8,013/ha—have a favorable ERR > 10 percent, the first one being an estimated 18 percent ERR.
- 34 World Bank (December 2004).
- 35 Estimates of the value of water savings were based on two economic studies: Kristiansen (2000) and Turpie, Ngaga, and Karanja (2003).
- 36 The outbreak of civil conflict caused this planning program to be halted before it could be completed.

37 NEPAD-FAO (2004c).

- 38 An additional US\$1.5 million would be spent on project coordination. No mention is made of irrigation system costs or whether they are included in this total so they have been assumed to not be included. Total proposed project cost would be US\$30 million.
- 39 Thirty percent in year 1; 50 percent in year 2; and 20 percent in year 3.
- 40 In figure 4-1 HS and MS are respectively high and medium storage costs; MI and LI are respectively medium and low irrigation investment costs. GVA is gross value added.
- 41 The concept is to identify all the direct and indirect use and nonuse values associated with the dam and reservoir, and to value them so that the cost can be divided or allocated using, for example, the separable cost, remaining benefits method. The technique of identifying all direct and indirect use and nonuse values is the same as that used by Turpie et al. (1999) to study the Zambezi wetlands. See also Dixon et al. (1986) and also World Bank (2005h, "Shaping the Future of Water for Agriculture: A Sourcebook for Investment in Agriculture Water Management"). Innovation Profile 9.3, Estimating the Multiplier Effects of Dams.
- 42 Kikuchi et al. (2004).
- 43 Unit total cost is defined as the total capital investment cost of an irrigation project divided by the total irrigated area benefited by the project—non-irrigation-related costs are excluded. Unit hardware cost is defined as unit total cost less so called software costs. Hence, unit hardware cost consists of all costs related to physical construction, excavation, structures, facilities, equipment, and materials, such as dam, canal, irrigation road, sluice, water-gate, and construction materials.

CHAPTER 5

- 44 Examples include the Zambia Agribusiness Technical Assistance Center. See World Bank (2005) "Shaping the Future of Water for Agriculture: A Sourcebook for Investment in Agriculture Water Management." Innovation Profile 1.2, and the National Smallholder Farmer's Association of Malawi.
- 45 Adapted from Tanzania NIMP Action Plan Report, Vol. I. (Nippon Koei 2003).
- 46 Byerlee and Jackson (2005).
- 47 The Namibian Water Policy (2000) describes the intention to move toward the adoption of an integrated, basin-scale framework for water resource assessment and management, but does not actually establish a new institutional framework to implement this. Instead, it focuses on delineating the broad functions that should exist in the sector—resource management, regulation, service delivery, policy, and strategy—and suggests modest changes in the present centralized administration to carry this out. No mention is made of payment for bulk water supply or establishing a source of revenue for the sector institutions that would free them from their present budget starvation. The reluctance to move more decisively can be explained in part by the presently complex situation with regard to land reform and decentralization. The roles of newly elected regional councils—and their relation to traditional authorities in the communal areas that dominate in the northern, more humid zone of the country—are in a long transition.
- 48 Autonomous Regional Water Administrations (ARAs) have been created under the decentralized water management system under implementation in Mozambique. Two ARAs are fully established and a third, for the Zambezi Valley, is in the process of being established, in all likelihood with substantial

European Union support. The ARAs are responsible for allocating water use permits and bulk water supply. ARA-South indicated that the current water tariff for agriculture users is 40 Mt/m³. This implies a bulk water supply cost for a 1 ha farm of about 480,000 Mt per season, or about US\$21 per season or US\$0.002/m³ at current exchange rates. ARA-South reported that a major tariff revision study is underway. Current revenues from all water users (agriculture, municipal and rural water supply, and the electricity utility) only cover about one-third of recurrent costs, which include O&M, and provide no financial basis for arranging for investment urgently needed new in infrastructure, including dams.

49 Revisions to the 1949 Water Act that would establish the National Water Resources Management Authority are based on long and wide consultation within the country and are now before Parliament. Adoption is expected in late 2005 or early 2006. Meanwhile, DANIDA is working with the Water Resources Action Programme (WRAP), who has been the prime mover behind this major reform, to develop and implement a program to implement the provisions of the act in a single pilot basin, most likely the Kafue basin.

50 World Bank (November 2005).

51 There is one instance in an existing scheme in which water is delivered by canal. There is extensive theft of water from this canal upstream of the scheme area, which the large commercial farmer and the smallholders are paying for, but there does not exist as yet enough social capital within this group for them to assert their ownership of the water without pleading for intervention by the government, which is not forthcoming and in all likelihood would not be effective.

52 The Green Scheme Coordinating Commission reports that it has a long list of interested investors, and that the call for applications by potential small-scale farmer participants is vastly oversubscribed. Its difficulty in the latter regard appears to be finding enough qualified candidates. The selection criteria include, among other things, education level, marital status, farming experience, especially knowledge of the commercial environment. Preference is given to a local community member, a previously disadvantaged group member, or a person with the lowest household earnings.

CHAPTER 6

53 The ZACPRO 6 reports forecasted the irrigated area in 2015 to grow to about 260,000 ha from a base of 171,000 ha in 1995.

54 There are important hydrologic and economic tradeoffs between numerous small upper catchment storage reservoirs and a small number of large multipurpose reservoirs, or a combination of small, medium, and large reservoirs strategically located in different parts of a basin.

55 Allocating net storage costs to an irrigation scheme does not mean that farmers must pay this cost. Cost allocation is necessary to evaluate the economic viability of the irrigation scheme based on all costs that are directly and indirectly attributable to the scheme with all subsidies removed.

56 For example, early success creates opportunities for farmer-to-farmer awareness building and training opportunities.

57 World Bank (2005, "Toward a Strategy for Agricultural Development in Angola: Issues and Options").

ANNEX A

58 This section is based in part on a consultant briefing for the World Bank on Zambezi River Basin management by K. John Shepherd, June 2005.

59 Including all of the Zambezi River riparian countries. Subsequently modified and revised in 2000.

60 The ZRA operates the Kariba Dam and Reservoir, selling water to the Zambian and Zimbabwean electricity utilities to generate power at their respective hydroelectric plants.

61 The terms watershed and catchment are used interchangeably in this report since the Zambezi countries have not yet adopted a common nomenclature. In this report, these terms simply refer to the physiographic drainage area of a river at whatever level of the overall river network is indicated by the context of the discussion.

62 These demands are not limited to withdrawal of water for drinking, industry, or agriculture, but apply equally to new hydropower facilities, flood control, prescribed flooding, or environmental flows.

63 Although national water plans existed in a number of countries at this time, some were incomplete and others were already out of date. There also appears to have been little capacity in place that would be able to do the analytical work to properly assess the implications of the proposed agreement.

64 These cost estimates are indicative at best.

65 World Bank (September 2005, "Meeting the Challenge of Africa's Development: A World Bank Action Plan").

ANNEX B

66 The point where the upper basin terminates (as one moves downstream) is traditionally taken as the location on the main stem of the river above Victoria Falls that is common to Zimbabwe, Botswana, Namibia, and Zambia.

67 This and the other hydrographs in this annex are taken from Beilfuss and dos Santos (2001).

68 Beilfuss and dos Santos (2001).

69 According to ZACPRO 6, Sector Study 5, hydrological conditions for Lake Kariba have changed remarkably during the period since the dam was built. The inflow to Lake Kariba has been greatly reduced, as average annual inflow for the last 15 years has been only a little more than half of the average annual inflow during the period 1961–1981. There has been no spillage since the operational year 1981–1982, while spillage occurred in all previous years except one.

70 The Kariba Reservoir on the Zambezi and the Itzhi-Tezhi Reservoir on the Kafue provide a significant degree of regulation to Zambezi River inflows to Cahora Bassa reservoir and the lower basin.

71 Four cycles have been reported in the record between 1907 and the mid-1990s: 1) a dry period from 1907 to the 1920s; 2) average rainfall between the 1920s and about 1948; 3) a wet period extending from 1948 to 1980; and 4) a dry period beginning in 1981 and extending up to the present (DENCONSULT 1998).

72 Beilfuss et al. (2001).

73 DENCONSULT (1998).

74 Sharma and Nyumbu (1985).

75 Their remarks concern primarily the headwaters region of the upper basin where small plots are frequently cleared and burned for seasonal agriculture. Most of this region is still covered in dense forest. This issue may be of much greater concern downstream in the more intensively developed and developing sub-basins such as the Shire River–Lake Malawi basin. Rates of deforestation in Malawi (about 1.5 percent per year) are at least three times greater than in Mozambique (although it is quite severe in parts of sub-basin 1-02 in Tete), Zambia, and Zimbabwe, and there is evidence of widespread watershed degradation, soil erosion, and siltation of river channels in Malawi. (See, for example, Hirji et al. [2002]).

- 76 DENCONSULT (1998).
- 77 For example, the priority environmental management areas summarized in B-9 or any of the natural wetlands and floodplain areas (where there is an at least locally important capture fishery) as depicted in B-8 that provide environmental and water resource management services of economic and social importance.
- 78 The existence of long-term power purchase agreements (contracts) exacerbates this constraint on upstream water development and use, especially in areas such as the upper Zambezi where development of water resources has been delayed by a number of other development and economic constraints.
- 79 Beilfuss et al. (2001).
- 80 Turpie et al. (1999) and Hirji et al. (2002).
- 81 Mozambique is actively considering and promoting a second powerhouse at Cahora Bassa and a new reservoir and hydropower facility downstream of Cahora Bassa at Mepanda Uncua—reportedly to operate at least initially as a ROR plant relying on the storage at Cahora Bassa upstream. The mission was told that discussions have been held with the South Africa electricity utility for joint development of this new facility.
- 82 The main exception is the collection of rivers that form the upper basin, in particular the upper Zambezi, Cuando-Chobi, Luanginga, and Lungue Bungo rivers that are shared by Angola, Namibia, Botswana, and Zambia.
- 83 There are a number of additional hydroelectric projects proposed along the main stem of the Zambezi besides these two new projects (Batoka and Mepanda Uncua). These—along with the proposed additions to hydroelectric capacity on the Kafue at Itzhi-Tezhi and lower Kafue gorge—appear to be the projects most likely to move forward in the foreseeable future. Nevertheless, in doing a strategic analysis of the Zambezi River, the addition of other proposed hydroelectric projects would be important to also consider in order to assess the implications of a sufficiently wide range of development scenarios that reflect possibilities over the long term.
- 84 The shape of the inflow hydrograph to Cahora Bassa is very similar to the historical hydrograph despite the uniformity of outflow from Kariba because the pattern of outflow from the middle basin is now governed by the Luangue and other middle basin rivers. Even though Kariba has not spilled since about 1980, high flood inflows have been experienced at Cahora Bassa because of extreme events in these intervening sub-basins.
- 85 This is, of course, not precisely true on a daily, weekly, or seasonal basis, or from year to year, but it is nearly so at the macrolevel of analysis. Should the Zambezi basin experience another average or high rainfall cycle, the pattern of outflows from Kariba could change substantially as figure B-10 suggests. It may also be possible that the operating regime and, consequently, the outflows from Kariba's powerhouses may change monthly or seasonally—or over shorter time intervals if the new capacity is primarily for peaking—when and if the additional capacity is constructed.
- 86 The Marromeu Complex, about 5,000 km², is located along the southern bank of the lower Zambezi River and includes the Marromeu Buffalo Reserve and three managed hunting areas. There are proposals to link the management of Marromeu to the Gorongosa National Park to the south to

form a single large protected area system. Marromeu includes wetland habitats that range from floodplain grasslands, to papyrus swamps, to mangrove swamps that support rare, vulnerable, and endangered species, and an ecosystem of great national and global importance.

- 87 Beilfuss et al. (2001) and Beilfuss and Bento (1997).

ANNEX C

- 88 IFAD (1999).
- 89 FAO (2004, Zimbabwe).
- 90 Government has facilitated the entry of private sector operators in the major cities by creating two agencies: FIPAG is the owner of water supply system assets and is responsible for promoting their autonomous, efficient, and profitable management through various types of contracts with private operators; and CRA who is the regulator responsible for oversight of tariffs and level of service.
- 91 While it is a long way from the river to the tap in Maputo, in terms of infrastructure and other costs, ARA-South reported that the average price of water at the tap in Maputo is 11,000 Mt in sharp contrast to the raw water cost of 70 Mt paid to ARA-South for that water.

ANNEX D

- 92 These criteria have been adapted from the initial eligibility criteria included in the Malawi Irrigation, Rural Livelihoods, and Agricultural Development Project recently approved by the World Bank. As the program progresses, the criteria would commonly be reviewed and can be adapted to better reflect conditions on the ground in order to maximize the probability of achieving the program's objectives.
- 93 An agreement on water sharing with Angola exists for the Kunene River basin, and a permanent joint commission consisting of Angola, Namibia, and Botswana exists (OKACOM) to manage the Okavango River. The new Zambezi Watercourse Agreement (ZAMCOM) has not yet come into force.
- 94 There is one instance in an existing scheme in which water is delivered by canal. There is extensive theft of water from this canal upstream of the scheme area, which the large commercial farmer and the smallholders are paying for, but there does not exist as yet enough social capital within this group for them to assert their ownership of the water without pleading for intervention by the government, which is not forthcoming and in all likelihood would not be effective.
- 95 The Green Scheme commission reports that it has a long list of interested investors, and that the call for applications by potential small-scale farmer participants is vastly oversubscribed. Its difficulty in the latter regard appears to be finding enough qualified candidates. Selection criteria include, among other things: education level; marital status; and farming experience, especially knowledge of the commercial environment. Preference is given to a local community member, a previously disadvantaged group member, or a person with the lowest household earnings.
- 96 Zambia (May 2005).
- 97 World Bank (November 2005, Zambia)

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