Efficient Water Use for Agricultural Production (EWUAP Project

AGRICULTURAL WATER IN THE NILE BASIN –AN OVERVIEW

By

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Indicative Exchange Rates (31 January 2008)

Country	Currency	Rate to US$
Burundi	Burundi Franc (FBu)	1100
DRC	Congo Franc	567
Egypt	Egypt £	5.5
Ethiopia	Ethiopian Birr	8.9
Kenya	Kenya Shilling	64
Rwanda	Rwanda Franc	545
Sudan	Dinar	200
Tanzania	Tanzania Shilling	1000
Uganda	New Uganda Shilling	1700

Acronyms and Abbreviations

ADB	African Development Bank
AEZ	Agro-Ecological Zones
BCM	Billion Cubic Meters
BP	Best Practice
BoQ	Bill of Quantities
CMI	Community Managed Irrigation
CMIWG	Community-Managed Irrigation Working Group
ASALs	Arid and Semi-Arid Lands
CGIAR	Consultative Group on International Agricultural Research
CIDA	Canadian International Development Agency
CRS	Catholic Relief Service
DRC	Democratic Republic of Congo
DRWH	Domestic Roof Water Harvesting
DSS	Decision Support System
EIRR	Economic Internal Rate of Return
ENSAP	Eastern Nile Subsidiary Action Project
ENTRO	Eastern Nile Technical Regional Office
EWUAP	Efficient Water Use in Agriculture Project
ET_o	Reference Evapotranspiration
EU	European Union
FAO	Food and Agriculture Organisation
FCT	Ferro Cement Tank
FFS	Farmer Field School
GAA	German agro-action
GDP	Gross Domestic Product
GEF	Global Environment Facility
GIS	Geographic Information system
GTZ	Germany Agency for Technical Cooperation
ICARDA	International Centre for Agricultural Research in the Dry Areas
ICB	International Competitive Bidding
ICCON	International Consortium for Cooperation on the Nile
ICR	Implementation Completion Report
ICRAF	International Centre for Research in Agroforestry
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IFAD	International Fund for Agricultural Development
ILRI	International Livestock Research Institute
IO	Irrigation Organisation
IPM	Integrated Pest Management
IWMI	International Water Management Institute
IWRM	Integrated Water Resources Management.
JICA	Japan International Cooperation Agency
KBO	Kagera Basin Organization
MCM	Million Cubic Meters (Mm^3)
M&E	Monitoring and Evaluation
NBI	Nile Basin Initiative
NBTF	Nile Basin Trust Fund
NCB	National Competitive Bidding
NELSAP	Nile Equatorial Lakes Subsidiary Action Project
NEPAD	New Partnership for Africa's Development
NGO	Non-Governmental Organization
Nile-COM	Council of Ministers of Water Affairs of the Nile Basin States
Nile -SEC	Nile Basin Initiative Secretariat
Nile-TAC	Nile Basin Initiative Technical Advisory Committee
NPC	National Project Coordinator
NTEAP	Nile Transboundary Environmental Action Project
O&M	Operation and Maintenance
PAD	Project Appraisal Document
PMU	Project Management Unit
PIP	Project implementation plan
PPMI	Public/Private Managed irrigation

PMIWG	Public and Private Managed Irrigation Working Group
PRC	People's Republic of China
PSA	Project Services Agency
PSC	Project steering committee
PUWR	Potentially Utilizable Water Resources
PWS	Primary Water Supply
QCBS	Quality and Cost-Based Selection
RBA	Rapid Baseline Assessment
RWH	Rainwater harvesting
SAP	Subsidiary Action Program
SC	Steering Committee
SSI	Small Scale Irrigation
SIDA	Swedish international Development Agency
SLM	Sustainable Land Management
SVP	Shared Vision Program
SWC	Soil and Water Conservation
TAC	Technical Advisory committee
TOR	Terms of Reference
UNDP	United Nations Program for the Development
UNOPS	United Nations Office for Project Services
USAID	United States Agency for International Development
WB	World Bank
WFP	World Food Programme
WH	Water Harvesting
WHWG	Water Harvesting Working Group
WUAs	Water Users Associations (also see IO)

Note: For Acronyms by Country, see Annex J.

Glossary

General	
Brick Tank	A tank constructed from bricks
Ferro Cement Tank (FCT)	The structure/frame of the tank is usually made from wire mesh and a mortar of sand and cement is used to make the wall
Hectare (ha)	10,000 m^2 = 2.471 acres
Blue water:	Equivalent to the natural water resources (surface water and groundwater runoff)
Green water:	Rainwater directly used and evaporated/transpired by non-irrigated agriculture, pastures & forests.
Agro-ecological zones	Agro-ecological zones defined by FAO on the basis of average annual length of growing period for crops, which depends inter alia on precipitation and temperature. The lengths are: humid > 270 days; moist sub-humid 180-269 days; dry sub-humid 120-179 days; semi-arid 60-119 days & arid 0-59 days.
Deficit irrigation	Deficit irrigation is the application of less irrigation water than that required for maximum plant growth, to optimize yield per unit of water rather than land – in other words, to optimize water productivity
Farmers' Field Schools	Farmer Field Schools are a way of testing and adapting new technologies. They consist of a community-based, practically oriented, field study programme, involving a group of farmers, facilitated by extension staff (public or private) or, increasingly, by other farmers, in which farmers learn together and test/adapt practices, using practical, 'hands-on' methods of discovery learning that emphasize observation, discussion and analysis to combine local indigenous knowledge with new concepts.
Food security	Food security is the condition of being able supply one's food needs either from one's own production or by buying in from other sources, whichever is more economically advantageous. Food security may be expressed in terms of the household, the nation or the region.
Irrigation	Comprises operations to supply additional water to agricultural land to augment rainwater (if any) for the purpose of crop growth. Irrigation water may be supplied from groundwater, surface water, agricultural drainage wastewater or other wastewater (including from domestic or industrial use). For the purpose of this report, reference to irrigation includes drainage where appropriate.
Supplemental irrigation	'Supplemental' (or supplementary) irrigation involves providing water to augment rainfall for crop growth. Most irrigation is supplementary, except where it is provided entirely within a dry season.
Egypt	
Feddan	0.42 ha [2.375 Feddan = 1 ha]
Ardab	Wheat ~ 150 kg
	Maize ~ 140 kg
	Rice ~ 120 kg
	Bean ~ 155 kg
Cutl	Barseem ~ 150 kg
Kantar	Cotton ~ 157 kg
Ethiopia	
Bereha	Hot and hyper-arid): General term that refers to the extreme form of Kola, where annual rainfall is less than 200-mm.
Dega	Cool, humid, highlands): Areas from 2500-3000 meters where annual rainfall ranges from 1200 to 2200-mm
E.C.	Ethiopian Calendar (Add 8 to convert to Gregorian calendar)
Kebele	Lowest administrative unit below a district
Kola	(Warm, semi-arid lowlands): Areas below 1500 m with annual rainfall ranges from 200-800 mm.
(Weina Dega	(Temperate, cool sub-humid, highlands): Areas from 1500 to 2500 m, where annual rainfall ranges from 800-1200-mm
Woreda	District
Wurch	(Cold highlands): Areas above 3000 meters and annual rainfall is above 2200-mm
Tanzania	
Charco Dam	Small Earth Storage Dam
Lambo	Charco Dam
Jaluba	Bunded field
Ndiva	Storage reservoir
Uganda	
Matoke	Green banana cooked for food. Staple food in Uganda
Valley dam	On stream embankment for trapping and storing of surface runoff from a catchment's area
Valley tank	On stream valley excavation of a reservoir for trapping and storing surface runoff from a catchment's area

Glossary of Terms and Definitions

Definitions		Remarks
Efficient water use for agricultural production	The optimisation of water used in agriculture for acquiring the maximum crop production per unit of consumptive use and to minimise the amount of water diverted to the agricultural land to meet this consumptive use.	
Benchmark.	The designs value of process output (or performance indicator). The benchmark level is set by comparison with the best practices of comparable processes.	
Performance assessment (in irrigation & drainage)	A systematic observation, documentation and interpretation of activities related to irrigated agriculture with the objective of continuous improvement.	Benchmarking of schemes is important in this process
Best Practice (in Irrigation and Water Harvesting)	The Best Practice is one that gives optimum utilization of land and water resources for sustainable agricultural production and environmental management.	Definition of best practice varies according to the purpose to which it is to be put. In irrigation & water harvesting it relates to 5 main issues: Technical; Economic; Social; Management, Operation & Maintenance (MOM); Institutional.
	A good example of what can be achieved in irrigation and drainage or Water Harvesting and can be used for Benchmarking of systems as well as providing models for wider dissemination.	
Irrigable area.	Area (in hectares) with physical infrastructure that enables the delivery of irrigation water.	
Irrigated area.	Part of the irrigable area to which water is actually delivered during the growing season of the irrigated crop	
Cropping intensity	<u>Total area cultivated during the year</u>	
	Command area	
Irrigation intensity	Number of irrigation seasons per annual cycle	
Delivery performance ratio or Management performance ratio	<u>Actual supply discharge</u>	
	Target discharge	
Depth of delivered water.	Volume of water delivered to a certain offtake divided by the size of this area.	This depth commonly has the same dimensions as precipitation and Evapotranspiration (e.g. mm/day).
Conveyance efficiency	<u>Volume of water delivered (to tertiary unit)</u>	
	Volume of water diverted/pumped from source	
Distribution efficiency	<u>Volume of water received at field</u>	
	Volume of water delivered (to tertiary unit)	
Field application efficiency	<u>Volume of water needed by crop (crop ET_P - effective rainfall)</u>	
	Volume of water received at field	
Irrigation system efficiency	<u>Volume of water received at field</u>	
	Volume of water diverted/pumped from source	
On-farm efficiency	<u>Volume of water stored in the root zone</u>	Expresses role of soil water holding capacity
	Volume of water received at field	
Reference ET	ET of unstressed short clipped and well watered grass	Defined according to FAO 56 guidelines
Crop coefficient	factor that converts reference ET into potential ET	
Potential ET	Consumptive use of an unstressed crop	
Actual ET	Consumptive use of an stressed crop	Stress could be caused by water, salts and heat
Crop water stress	ETp - ETa	Deficit in consumptive use
Crop water requirements	ET_p - effective rainfall	

Effective rainfall	Amount of rainfall that is infiltrated into the soil profile and subsequently available for consumptive use	
Irrigation water requirements	Water requirements for crops and leaching	
Bio-physical crop water productivity (kg/m3)	Yield of harvested crop / Consumptive use	Consumptive use comprises rainfall, irrigation, capillary rise and moisture depletion
Economical crop water productivity (US$/m3)	Value of harvested crop / Consumptive use	

References

a/.	Bos and Nugteren (1974; 1990)	d/.	Boss, M..G.; Burton, M. A.; Molden, D.J.; (2005)
b/.	ICID (1978)	e/.	Proceedings of EWUAP Inception Workshop; Best Practices; Nov. 2007.
c/.	IWMI (1987; 1993)	f/.	FAO Irrigation and Drainage Paper 56

The information presented in this report reflects the views of the Consultant and does not necessarily represent those of the Nile Basin Secretariat. It has been compiled from data and information made available by the Project Management Unit (PMU) of the Efficient Water Use for Agricultural Production Project (EWUAP) together with much published data obtained from international organisations and from the internet. This has been supplemented with the knowledge and experience of the Consultant who has worked in most of the Riparian states at some time over the last 35 years.

Executive Summary

For the last decade, most countries in the Nile Basin had been classified as food insecure. In spite of investments and actions in all countries, this situation has not improved. All riparian countries have a limited capacity to absorb shocks such as drought and floods and high external prices. Regardless of efforts to establish long-term sustainable strategies, many interventions have been on short term nature (so called quick impact projects) without adequate longer term support. Production levels in all countries are lower than are needed to sustain their populations, and the recent rises in the world market price of wheat have shown how vulnerable they are. Even Egypt with its reforms, liberalisation and increasing industrial sector, has not been able to offset the shortages of wheat in early 2008. Population growth has exceeded crop production and with limited available arable land, there is increasing competition for jobs and high unemployment in rural areas. Water shortages remain in spite of considerable efforts to recycle drainage water and reuse of treated wastewater.

Many parts of the Nile Basin are dominated by poverty and armed conflicts, and these are the main determinants of food insecurity. Political wrangling and short term fixes has meant that measures are not in place to combat the vagaries of the weather, and the ever increasing number of mouths to feed. Insufficient attention has been given to removing agricultural constraints and providing adequate support to the farmers so that production can be raised. Furthermore, the application of research has not been sufficient, with limited attention paid to plants that have a high potential for improvement.

The major farming systems of the Nile Basin correspond with the main agro-ecological zones. Most of the rural populations engaged in agriculture occupy the higher potential sub-humid and humid zones. Studies reveal that approximately 80% of the upper Nile Basin's poor live in rural areas and depend largely on agriculture for their livelihoods. Agricultural growth is key to poverty reduction yet it remains a largely subsistence activity, with production not keeping pace with population growth. As a result, the number of malnourished people has steadily increased and food self-sufficiency declined.. Food and cereal crop production will need to expand rapidly in coming years not only to keep pace with population growth, but also to make inroads into poverty. The trend in voluntary movement of farmers to arid and semi-arid zones due to high land pressures needs to be supported, so that they are equipped with appropriate but different technologies such as conservation agriculture and water harvesting. Although agricultural water development in these places is often more costly and markets more remote, the favourable combination of land, water and access to markets in the drier areas can produce successful results. In the past, the lack of a clear understanding of the issues that link agricultural water development to poverty reduction and growth has been one of the reasons for underdevelopment of the sub sector[1]. Insufficient investments, inadequate involvement of farmers and support to them, including an ineffective central state management, have resulted in poor performance of many traditional and state irrigation schemes. These are characterized by low crop production (similar to rainfed lands), limited water use efficiency and poor irrigation infrastructure. There are no quick fixes or impacts. For successful interventions, a longer term commitment and better understanding by the donor community is needed to reduce the constraints facing farmers living in marginal areas. The situation has been further exacerbated by the lack of experienced technical professionals involved in decision-making. As a result, water sector strategies have not fully addressed the constraints experienced by both irrigated and rainfed farmers. By highlighting the overriding

[1] Poverty reduction strategies are based on agricultural growth, but agricultural water development has not been seen as a vehicle for achieving this and in fact, because of poor past performance and many preconceived ideas within the donor communities, it has been purposely excluded. Consequently it has had limited attention in such strategies.

issues such as agricultural extension services and marketing, this report aims to give more attention to overcoming some of the root causes.

In order to overcome the widening gap between production and demand, governments and donors have attempted to increase production by the expansion of geographical areas rather than improvement of productivity on existing developed areas. Consequently, investment returns have not been good, and the relatively high cost of irrigation systems has deterred donors and financiers from supporting new systems. Investment in agricultural water can contribute to agricultural growth and reduce poverty directly by (a) permitting intensification and diversification on already developed land and raising farm outputs and incomes; (b) increasing farm employment and discouraging migration to urban centres in search of better wages; and (c) increasing availability of food on local markets, reducing local food prices and improving real net incomes.

The potential for improvement in agricultural productivity across the Nile Basin has shown the need for a change of focus by governments and donors. Some governments have already established irrigation master plans that provide increased emphasis on irrigation developments. These need to be supported by parallel and complimentary activities in the agricultural sector, covering those aspects that are common to both rainfed and irrigated agriculture. Water harvesting however, has not formed part of the equation in the water sector reforms and in the draft legislation prepared to support them Arguably, there is a need to mainstream water harvesting in both national policy and supporting legislation, to make planners and politicians aware of the important role that it has to play in both poverty alleviation and improving the economy. Realistic goals need to be established for both water harvesting and irrigation building systematically upon successful technologies and approaches instead of assuming a blanket and widespread up-scaling.

Public irrigation development in the Nile Basin countries has been excessively costly in the past with few schemes realising the predicted returns and true potential. Irrigated agriculture in the Upper Nile Basin continues to be characterized by low productivity and hence low profitability. As many of the capital costs are sunk, attention must be given to making these systems perform, as well as introducing complimentary rainwater water harvesting into the rainfed and semi-arid areas. Although low productivity is correlated with unreliable water supplies, low input use and difficulty in accessing profitable output markets it is mainly reflected by the lack of incentives for change by most subsistence farmers. Expansion into new areas to increase production has not been a successful strategy, and needs to take a second place while all countries get their irrigation systems in order. The improvement in agricultural productivity needs to be a two pronged approach involving the upgrading of rainfed agriculture through enhancement in land quality and water, and drought management (using in-situ water harvesting techniques and integrated catchment's management). In parallel with this, there should be longer-term commitment for the support of irrigation and water harvesting needs, thus ensuring the proper construction of infrastructure, utilisation and management.

The provision of irrigation water alone will not guarantee increased productivity, as any assistance afforded take into consideration the wide variety of constraints experienced by irrigation and rainfed farmers. Strategies which provide incentives for change such as improved access to inputs, reasonable returns and adequate market access need to be developed. Despite the fact that not all communities may have access to irrigation, many can reduce the risks faced as a result of climate vagaries, through the utilisation of technologies for in-field rainwater management, which are best suited for dryland crops. These interventions will increase the effectiveness of rainfall, and coupled with structural storage of runoff to meet other needs of their farming systems, will permit additional income generating activities.

Operation and maintenance of irrigation developments has been one of the main weaknesses of the irrigation systems in the Nile Basin. In spite of considerable efforts to train and involve the farmers, once project support has been removed, many failed to meet donor expectations. This is due to the fact that funding collected from the communities for O&M, can only meet reactive maintenance needs. Evidence suggests that concerted efforts have been made to involve beneficiaries in the planning, operation and maintenance of the schemes. However, there is still the tendency of decision makers, designers and technical staff alike, to deem the farmers as ignorant. Often, it is perceived that once the farmers are consulted, they will understand all of the underlying thinking, designs, approaches and rationale of implementing and applying the water harvesting, and small-scale irrigation interventions. There are a good number of successful examples of water harvesting and small-scale irrigation schemes in each of the Nile Basin countries. Nevertheless, the encouragement of the up-scaling of the aforementioned techniques and approaches to other areas still remains a challenge. Studies reveal that the blueprint approach does not work as each community has its own nuances, which means that developments and interventions must be tailored to the farmer's aspirations and perceptions of risk. The support for interventions and development requires the commitment of a minimum of 10 years, involving capital investments, as well as efficient extension support to work with communities, and make them strong and cohesive in terms of the management of their resources. Seemingly, politics can both hinder and assist in the process of up-scaling the improvement of productivity of existing irrigation systems. By and large, the political commitments to the agricultural sector have been minimal, with governments failing to adequately invest in agricultural development.

Examination of agricultural water use within the Nile Basin highlights the need for a more holistic approach that reflects the needs and expectations of the communities, and allows for the development of integrated water resources management. It is essential that farmers understand the benefits of investing in new technologies, in order to improve agricultural productivity. In many cases, farmers in the rural areas have been reluctant to cultivate new crop varieties, due to the vagaries of rainfall and water insecurity, including the availability and high prices of fertilisers and other agricultural inputs. Evidence from the Rapid Baseline Assessments show that efforts have been undertaken to increase agricultural production by improving inputs, water, access to credit and markets, as well as the provision of good agricultural extension services. Nevertheless, the rural farmers across the Nile Basin continue to be plagued by inadequate access to markets, as well as insufficient or non-existent extension advice and support.

Watershed management has an important transboundary role in the Nile Basin if it reduces sedimentation, flash flooding and stabilises base flows. While evaluations have shown that upland communities have benefited to some degree from watershed management interventions, the payback for downstream users has been greater. Understandably, benefits accruing to the poorer communities in the upper watersheds have been slow to materialise, and have been relatively small in relation to labour inputs. In practice, some of the expected benefits may materialize only in the long term, resulting in the failure to complete agricultural activities, particularly when donor support has been withdrawn. All in all, watershed management interventions are complex and costly, and their sustainability is determined by the continual promotion of conservation practices. Quick investment returns are needed, in order to motivate the rural farmers. Conservation farming and in-situ water harvesting techniques have both produced promising results depending upon the climatic zone. However, adaptation by smallholders has been generally poor, with an exception of areas where it has been possible to establish market linkages. Many so called "successful" interventions have been donor driven, with the withdrawal of project support resulting in the collapse of benefits. Often, there is a lack of genuine commitment (involvement) from the farmers. Furthermore, the approaches introduced are too sophisticated, and are seemingly beyond the realistic capacity of the communities, as far as the farming systems and farmers understanding of risk and investment returns are concerned. External factors play an important part in this process and can be very difficult to overcome at the project level. For example the poor productivity on the large investments by IFAD into small scale irrigation schemes in Ethiopia, has been partly attributed to sector-wide constraints due to poor support services, inadequate district infrastructure, poor enabling environment and insufficient access to input/output markets.

Institutional constraints include inadequate legal frameworks for land, water and farmers' organizations, conflicting approaches of public agencies for investment and management. This is exacerbated further by the lack of empowerment of farmers to manage their water resources, who lack access to effective agricultural support services, finance and markets. Without reforms, productivity and farm level profitability will continue to be constrained. The role played by women in most production systems must be recognised when addressing these issues with approaches specifically targeting them and encouraging their participation. This has been found to enhance productivity and poverty reduction impacts.

Public-private and donor partnerships within the basin need to be strengthened and developed. Investors will not become involved in irrigation and water harvesting unless the returns are good and the enabling environment is conducive for their investment. Many sites for irrigation and water harvesting in the remote areas are served by poor roads and communication infrastructure. The private sector is reluctant to go into these areas as they are able to invest their money more easily in areas that have better communication and fewer constraints. Governments across the Nile Basin must consider this carefully to ensure that there are incentives for those prepared to become involved in the rural areas. Currently, great success has been achieved by the private sector the private sector in their association with tea, rice, sugar and cut flowers, the production of which has been undertaken with minimal involvement (and interference) of the public sector.

A wealth of technical information on RWHY and CMI already exists, which includes good examples of best practice throughout the Nile Basin. However, there are insufficient mechanisms for disseminating this knowledge and experience across the Basin and between practitioners in each country. In the case of rainwater harvesting, the efforts of RELMA and the Swedish government support have been remarkably successful. Similarly, throughout southern Africa, there is a good network of rainwater harvesting associations that meet regularly and exchange ideas and knowledge. Nevertheless, this is mainly in the NGO sector, thus more concerted efforts are required by governments, in order to utilise the knowledge and experiences for wider up-scaling throughout the basin. This does not mean interference by government, on the contrary it ensures a long term and more coordinated political commitment to the approaches and the role that rainwater harvesting has in poverty alleviation. Similar organisations are needed for the small-scale and community irrigation sector. Research has shown that there is a lack of a forum for exchange of ideas and practices by practitioners and users in most countries and certainly no such organisation exists across the Nile Basin.

There is considerable scope for improving agricultural productivity through support to existing users and the up-scaling of technologies and approaches used in some Nile Basin countries. The Nile Basin Commission, facilitated by the EWUAP project, provides an excellent vehicle for the sharing of ideas and experiences amongst the Nile Basin countries, to enhance the effectiveness and profitability of investments in the sector. Priority areas for investments are emerging and these will be examined further during Phase 2 to include (more details are given in section 6):

Overall (for both RWH and CMI)

(a) Establishment of an Enabling Environment;
(b) Mainstreaming of Activities and support into Governments Development Programmes.

(c) Institutional Development and Capacity Building including Water Users Associations;
(d) Presentation of appropriate technologies and approaches for wider use and up-scaling;
(e) Improved extension support including the availability of appropriate technologies;
(f) Market development including linkages with buyers;
(g) Training and support at field level;
(h) Applied research;
(i) Monitoring and evaluation of outcomes/results;

Water Harvesting

(j) Improved and Integrated Water Resources Management (IWRM) with greater community involvement;
(k) Consolidation of techniques available and wide dissemination of results;

Irrigation and Drainage Developments

(l) Improved water service delivery including irrigation service fees;
(m) Improved on-farm water management including raising productivity and facilitating efficient water use.

During the second phase of this assignment, the processes for facilitating water harvesting and small-scale irrigation within the Nile Basin will be established. Manuals and guidelines to support developments and deriving from existing knowledge within the basin will be prepared so that the successful experiences can be shared across the riparian countries. The preliminary identification of best practices and best practice sites will be developed further, to enable politicians and practitioners within the Nile Basin to see how others are approaching and dealing with similar problems. Essentially, this will enable those involved to consult with the beneficiaries and communities tasked with managing, operating and maintaining the systems developed. This report is structured into five parts. Part I establishes the objectives of the EWUAP project as well as water use in the Nile Basin, and provides an overview of all the factors that are considered to influence agricultural water use in the basin. In Part II, the situation relating to agricultural water use in the Nile Basin countries is examined, considering the situation in each country and discussing the issues that derive from the constraints that prevail. These discussions lead into the final part of the report were the sector development perspectives are set out. In Part III of the report, the aspects of best practice is discussed, firstly by establishing what best practice is and what is included both for water harvesting and irrigation, thereafter examining the preliminary results of the best practice studies carried out by National Consultants from most of the riparian countries. The establishment of best practices in the Nile Basin is an important part of Phase 2 of the current study and the results of this part of the report will be utilised and build upon in Phase 2. In Part IV of the report, an overview of the institutional and legal framework is presented. It examines the enabling environment for water harvesting and irrigation developments, and identifies stakeholders and institutions that could provide cooperating partners for the improvement and up-scaling of activities within the Nile Basin. In the final Part V of the report, initial ideas on sector development perspectives are established. These are obtained from the constraints and issues established upon the examination of each of the Nile Basin countries, and are used to initiate the discussion for solving the issues raised and to be supported by funding through the subsidiary action plans. Further work on this will be undertaken during Phase 2 of the assignment at the end of which, more detailed action plans and proposals will be prepared.

The time and resources made available for this current study have been limited, and there may well be omissions and errors that need to be corrected. As a result, the report will be circulated to the member countries for comment, but it must be realised that this is a dynamic process. Moreover, it is the first attempt under the Nile basin Initiative to bring together the common problems and ideas within the Nile Basin, with the intention of improving agricultural and water productivity. The report is targeted at water harvesting and small-scale/community irrigation. Parallel activities are being undertaken for the larger scale irrigation systems, and it is hoped that the approaches and methodology developed for those schemes can be utilised in a similar manner for the small-scale schemes.

The data and information presented in this report have been obtained from numerous sources, which include amongst others the Rapid Baseline Assessment Reports and Best Practices Studies (Drafts) prepared by National Consultants. On completion of the draft report, all stakeholders have had the opportunity to comment on the report, and these have been taken into consideration when preparing this Final Version of the Report. It should be noted that data from different sources is often conflicting and reflects the need for each member country to prepare up-to-date and corroborated definitive data. Through the process of data collection and examination by national consultants in each of the member countries, it has become evident that whereas there is a lot of general information available, there is a need for more detailed and precise information on each country. It is hoped that when the FAO Nile database has been completed, it will be made readily available to all users in member countries to enable the up-to-date assessments of potential, areas for intervention and identification of investments.

PART I: EWUAP AND WATER USE IN THE NILE BASIN

This report has been prepared to provide an overview of agricultural water use in the Nile Basin countries. While it draws on many sources, primary references have been made to the reports commissioned by EWUAP for River Basin Assessments and Best Practice Studies. These were prepared by National Consultants from each member country and should be consulted if the reader requires more detailed information. A full list of references is provided at the end of the report in Annex K – References.

In this introductory section of the report, the background to the study is set out and the objective of EWUAP outlined. The initial studies that were carried out as the basis for the work are briefly discussed and the follow up best practice studies by National Consultants are introduced. The requirements for this study are discussed together with the approach adopted. In Section 2, an indication of the situation in the Nile Basin and the general level of development of water resources in the riparian states are discussed. An overview of the changing climate and the available water resources, leads to the main issues that arise in connection with productivity. The section concludes with issues that need to be addressed if change is to be effected at community level. This part of the report therefore sets the scene for an examination of the current situation in the Nile Basin countries, and the issues that arise upon the examination of agricultural water use both by Water Harvesting and Community Managed Irrigation (Part II).

.1 INTRODUCTION

Population pressure, small land holdings and the impact of the vagaries of rainfall over the last 2-3 decades, has resulted in a gradual movement of the poorer rural population to arid and semi arid areas and to upper catchments which are unsuitable for crop production. Governments and donors have been slow to react to these problems. Urgent response in the form of appropriate actions and support is required in order to reduce the negative impacts of these changes, as well as to ensure that vulnerable communities are not displaced further. Arguably, these farming communities need proper guidance and training, in order to realise a sound and sustainable basis for their agricultural farming systems. Evidently, there is a lack of sufficient attention to the requirements of Integrated Watershed Management (IWM), including water harvesting and small scale community irrigation developments. This has been exacerbated by the effects of climate change, resulting in increased runoff and soil erosion that has affected the cultivated areas and the downstream riparian countries. Over the last decade, much has been written about how water harvesting should be carried out and implemented. However, governments have not taken ownership of the process and fewer farmers than would be expected have responded to pilot interventions. Despite the fact that numerous manuals and papers have been written and supported by experimental and demonstration areas in a number of the Nile basin countries, there is a lack of political commitment to support the ideas presented. Similarly, regardless of the clear benefits seen by those who are involved, interventions utilising runoff for drinking water, livestock water and agricultural production have not achieved the expected and desired large scale uptake. Each intervention cannot be regarded as large by government budget standards, but without their support and involvement, the up-scaling of the approaches and techniques proposed will continue to rely upon the NGO and private/voluntary sector, with their smaller and area specific funding. The major obstacle preventing the wider use of water harvesting and user managed irrigation developments appears to be that the end-users are still not convinced that they can afford the investments, and that they will benefit will from the mobilisation of their scarce resources that could perhaps be utilised better elsewhere. Rural communities comprise of a large proportion of small scale subsistence farmers who are risk averse and resource poor.

The Nile riparian countries, realizing their common concerns and interests over water and agricultural production, have made agreements towards cooperation by establishing the Nile Basin Initiative[2] (NBI), which is guided by a Shared Vision ***"to achieve sustainable socio-economic development through the equitable utilization of, and benefit from, the common Nile Basin water resources".*** It aims at cooperative development and management of the common Nile water resources and implementation through eight projects of NBI Shared Vision Programme[3] (SVP) that reflect this strategic shared vision. The aim is to create an enabling environment for the extensive Subsidiary Action Programs SAP (actions on the ground) that seeks to share benefits from the common Nile water resources. These will be implemented in two sub-basins: The Nile Equatorial Lakes Region; and the Eastern Nile Region. This report has been prepared under the SVP called the *Efficient Water Use for Agricultural Water Production (EWUAP)* Project.

1.1 Objective of EWUAP[4]

EWUAP started in 2006 as a three year programme, and has concentrated on training and capacity building in nine of the 10 member riparian countries[5]. EWUAP has been designed as a first step to bring together stakeholders in the Nile basin to develop a common shared vision on the increased availability and efficient use of water for agricultural production[6]. Through the involvement and informing of a broad range of stakeholders within the Basin, it is hoped that the understanding of the relationship between water sources and agricultural development will be improved, thereby enhancing basin wide practices and enabling many of the known interventions to receive greater support and wider application.

Following the earlier capacity building, promotional and sensitisation activities, and in preparation for this overview study, EWUAP-PMU contracted National Consultants in almost all NBI countries to prepare Rapid Baseline Assessments (RBA), detailing the current situation relating to agricultural water in each country. These studies were carried out prior to the Mid Term Review in May 2007, and aimed to establish the basis for the identifying commonalities and Trans-basin issues within the riparian countries.

1.2 Rapid Baseline Assessments (RBA)

The relatively limited time and resources allocated to the RBA studies meant that whereas fully comprehensive results may not have been achieved, the main issues have been captured and the process of addressing issues and constraints within the Nile Basin on a wider basis initiated. The approach adopted by EWUAP-PMU involved using National Consultants from each country who were both sufficiently experienced and actively involved in irrigation and water harvesting sectors. This enabled them to involve and consult the many stakeholders at community, regional and national level either directly or though the forum of workshops and consultative sessions. With such a broad range of stakeholders across nine countries, coordination and involvement may be slow. However, it is anticipated that through a better understanding of the relationship between water resources and agricultural development in the Basin, the scope for improving agricultural production and management capacities will become clearer and gain the support that is needed leading to possible interventions funded under NBI.

[2] Nile Basin Initiative (NBI) was inaugurated in 1999
[3] For full details go to NBI web site: http://www.nilebasin.org
[4] For more information go to EWUAP web site: (http://ewuap.nilebasin.org)
[5] The countries sharing the Nile Basin are: Burundi, Congo, Egypt, Eritrea, Ethiopia, Kenya, Rwanda, Sudan, Tanzania, and Uganda. Eritrea has observer status in the NBI program. (http://www.nilebasin.org/)
[6] World Bank. EWUAP. Project Appraisal Document. 2005.

All National Consultants responded to the terms of Reference[7], but there were wide variations in approach, content and quality of reports[8]. Those prepared for Ethiopia, Egypt and Tanzania covered the sectors well, but those from the remaining countries lacked sufficient details and information. Considerable time was spent in bringing the information presented into a common format and supplementing the RBA reports with additional data from FAO[9], CGIAR[10], IFAD[11], IMWI[12], World Bank and other sources[13]. Although knowledge transfer and data availability is improving within the member countries, it is still a major limitation on identification of development issues and constraints. This overview report utilises the above information to describe the situation within the basin and to identify constraints, issues and opportunities that exist.

1.3 Identification of Best Practice - National Studies

Additional national reports were commissioned by EWUAP following the recommendations of the Mid Term Review Mission (MTR), and in line with the agreed work plan and objectives of the EWUAP Project. These aimed to establish types and sites of Best Practices in each country, paying particular attention to the type of practice, the agro-ecological zone and whether there is potential for wider dissemination and up-scaling within the Nile Basin countries. This process was initiated prior to the arrival of the International Consultant[14] although work had not commenced on the studies. Learning from the outputs of the RBA studies and to ensure more consistent and comparable levels of data, the International Consultant spent time assisting the PMU to prepare definitions and reporting formats for the National Consultants as well as advice on report preparation and use of standard tables for presenting the results. In addition, the consultants were also asked to collect data omitted from the RBAs. The status and results of these consultancies are discussed in Chapter 4 with a shortlist of best practice sites deriving from each country presented in section 4.12. These will be taken forward in Phase 2 for further examination and possible dissemination in the Nile Basin.

1.4 Requirements of the Overview Study (TOR[15])

The current assignment forms Phase 1 of a study to review, evaluate, compile and produce basin wide overview on agricultural water sector of Nile Basin and related reports on best practices, stakeholders and future development perspectives. The specific objective of the assessment is to prepare the Regional Overview of the Rapid Baseline Assessments to:

(n) Identify the major weaknesses and opportunities in agricultural water management in the basin.

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[7] "*Rapid Baseline Assessment to complement country reports by collecting additional information & identifying opportunities and needs related to the exchange of best practices in water harvesting, community managed irrigation, and public/private managed irrigation*".

[8] RBAs are not available from Uganda and DRC as National Consultants were not identified for the studies.

[9] Aquastat. (http://www.fao.org/nr/water/aquastat/water_res/index.stm)

[10] Consultative Group on International Agricultural Research (CGIAR); established 1971; a strategic partnership of countries, international & regional organizations & private foundations (http://www.cgiar.org/)

[11] International Fund for Agricultural Development, a specialized agency of UN. (http://www.ifad.org/)

[12] International Water Management Institute, Nile Basin & East Africa Sub Regional Office (http://www.iwmi.cgiar.org/Africa/East/)

[13] See Annex K – References for more details.

[14] These studies were conducted during October & December 2007 with initial findings presented at the EWUAP workshop in Nairobi at the end of November. They will provide the basis for detailed follow under Phase 2 up to produce guidelines and best practice manual for utilisation in member countries.

[15] See Annex L – Terms of Reference for full details.

(o) Identify possible high potential best practices in agricultural water management with particular focus on water harvesting, community based (small scale) irrigation and medium/large scale irrigation, both publicly and privately managed.

(p) Identify and carry out a preliminary evaluation of national and regional stakeholders, including public and private professional and research organizations, water user representatives and community groups, including women groups and NGOs. A specific set of stakeholders to be analyzed would be basin wide institutions, associations, NGOs and think-tanks with potential to organize capacity building activities and implement field level demonstrations in the areas of water harvesting and irrigation. The EWUAP project may wish to work with some of these institutions in its "linkages and twinning" programme.

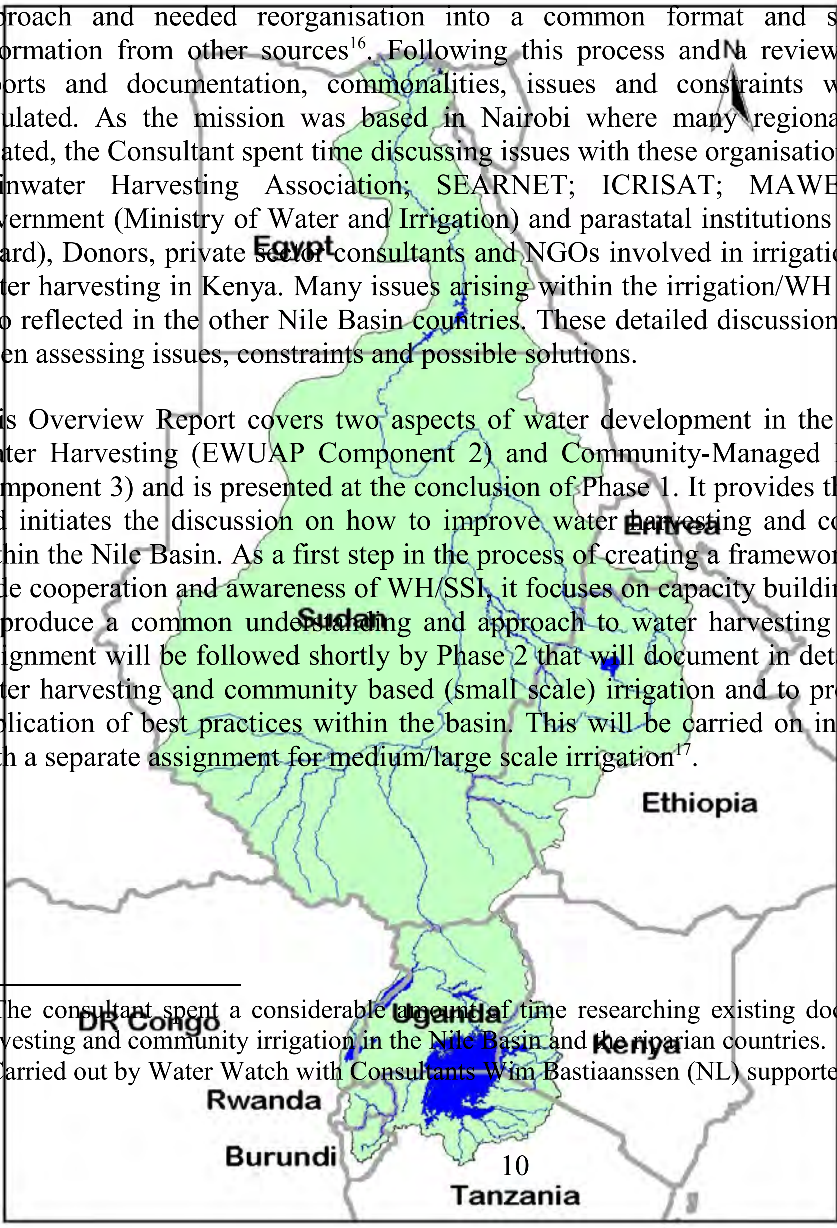
(q) Prepare a preliminary overview of future directions and possible investment priorities in agricultural water management in the basin.

The outputs of the envisaged work will be used to inform partners and stakeholders from Ministries of Agriculture, Ministries of Water and Irrigation, Technical Advisory Committee (TAC), and representatives of NGO, World Bank, Donors and Nile Secretariat.

1.5 Approach adopted for Consultancy

The Rapid Baseline Assessments (RBA) completed by the National Consultants formed the basis for the assignment. Upon review, these proved to be variable in quality, content and approach and needed reorganisation into a common format and supplementing with information from other sources[16]. Following this process and a review of other available reports and documentation, commonalities, issues and constraints were identified and tabulated. As the mission was based in Nairobi where many regional organisations are located, the Consultant spent time discussing issues with these organisations (ICRAF; Kenyan Rainwater Harvesting Association; SEARNET; ICRISAT; MAWESA;) as well as government (Ministry of Water and Irrigation) and parastatal institutions (National Irrigation Board), Donors, private sector consultants and NGOs involved in irrigation development and water harvesting in Kenya. Many issues arising within the irrigation/WH sector in Kenya are also reflected in the other Nile Basin countries. These detailed discussions proved invaluable when assessing issues, constraints and possible solutions.

This Overview Report covers two aspects of water development in the Nile Basin namely Water Harvesting (EWUAP Component 2) and Community-Managed Irrigation (EWUAP Component 3) and is presented at the conclusion of Phase 1. It provides the link with Phase 2 and initiates the discussion on how to improve water harvesting and community irrigation within the Nile Basin. As a first step in the process of creating a framework to promote basin-wide cooperation and awareness of WH/SSI, it focuses on capacity building and interventions to produce a common understanding and approach to water harvesting and irrigation. The assignment will be followed shortly by Phase 2 that will document in detail, best practices in water harvesting and community based (small scale) irrigation and to prepare guidelines for application of best practices within the basin. This will be carried on in parallel and linked with a separate assignment for medium/large scale irrigation[17].



[16] The consultant spent a considerable amount of time researching existing documentation on water harvesting and community irrigation in the Nile Basin and the riparian countries.
[17] Carried out by Water Watch with Consultants Wim Bastiaanssen (NL) supported by Chris Perry.

Figure 1.1 **Nile Basin and Riparian Countries**

2. OVERVIEW

2.1 The River Nile

The Nile River is the longest river in the world[18] and its basin covers more than 3,349,000 km^2. It comprises of two main tributaries, the White Nile and the Blue Nile, that are so named

[18] The length of the Nile from Lake Victoria to the Mediterranean Sea is 5,584 km and from Ruvyironza River in Burundi, the Nile is 6,671 km long. (Ref: http://ensap.nilebasin.org/).

because of the colour of the water. The source of the Nile is the Kagera River[19] that follows the boundary of Rwanda northward, turns where the borders of Rwanda, Uganda and Tanzania meet, and drains into Lake Victoria, which is the major significant source of the Nile and located in east central Africa. On leaving Lake Victoria at the site of the now-submerged Owen Falls, the Nile rushes for 483 km over rapids and cataracts, at first northwest and then west, until it enters Lake Albert. The section between the two lakes is called the Victoria Nile. The river leaves the northern end of Lake Albert as the Albert Nile[20], flows through northern Uganda, and at the Sudan border becomes the Bahr al Jebel. This enters the enormous swamps of the Sudd region of the Sudan where more than half of the Nile's water is lost to evaporation and transpiration[21]. At its junction with the Bahr al Ghazal, the river becomes the White Nile[22] and at Khartoum it is joined by the Blue Nile[23] that is 1,529 km long and rises at 2,150 m above sea level in the Ethiopian Highlands in a spring upstream of Lake Tana, where it is known as the Abbay. A length of 800 km of the Nile is navigable during high river stages and around 80% of Sudan's electricity is provided by hydroelectric schemes at Rosaries and Sennar on the river. These dams provide irrigation water for over 10,000 km^2 of the Gezira Plain. From Khartoum, the Nile continues to flow northwards through six cataracts to Aswan dam and onto the Nile delta (190 km wide) and the Mediterranean Sea. The Nile is navigable to the second cataract, a distance of 1,545 km.

Table 2.1 Nile Basin Overview

Basin area:	3.1 million km^2, including 81,500 km^2 of lakes and 70,000 km^2 of swamps
Basin population:	160 million, or 57% of the entire population of the basin's 10 riparian countries: Burundi, D.R. Congo, Egypt, Eritrea, Ethiopia, Kenya, Rwanda, Sudan, Tanzania, Uganda
Percentage rural:	Burundi, 93%; D.R. Congo, 71%; Egypt , 57%; Ethiopia, 84.6%; Kenya, 71.4%; Rwanda, 94%; Sudan, 67%; Tanzania, 75.8%; Uganda, 88.1%. Figures are for each country's entire population.
People below the poverty line ($1/day):	About 50%.
Per capita income range:	Between USD 100 and 790
Percentage contribution of agriculture to GDP:	Ranges from 17% in Egypt to 55% in Ethiopia
Mean annual rainfall:	615 mm, with a maximum of 2,060 mm
Climate:	Highly variable, with extremes manifested in floods and droughts
Primary water uses:	Irrigation, industry, domestic supply, hydropower, and navigation
Irrigated area of the basin:	5.5 million ha, with potential of 10.2 million ha
Environmental conservation areas:	More than 100 protected areas in 9 countries (excludes Eritrea). Total includes portions of countries not within the basin.
Source: Compiled from Report Data and other sources (FAO; CGIAR; NBI)	

[19] Also known as the Akagera river and gives its name to the Akagera National park in Rwanda.
[20] The flow rate of the Albert Nile at Mongalla is almost constant throughout the year averaging 1,048 m3/sec.
[21] The average flow rate in the Bahr al Jebel at the tail of the swamps is about 510 m³/s.
[22] *Bahr al Abyad* in Arabic.
[23] *Al Bahr al-Azraq* in Arabic.

Figure 2.1 **The Nile Basin**

2.2 Nile Basin Countries

The Nile Basin covers an area of about 3 million square kilometres that is shared by 10 countries[24] with a currently estimated population of 300 million. It is characterised by extremes in climate with exceptionally arid areas with limited rainfall in the North in Egypt, and humid wet areas in the South East in Ethiopia. Much of the basin does not contribute to the flows of the Nile River, as it comprises of arid or very arid zones. The main contributor is the June to November rainfall in the Ethiopian highlands that is often quite intense and causes rapid runoff and high sediment transport. In an average year, the basin receives about 650 mm of rainfall that translates into about 1,900 billion cubic metres (bcm) of annual flow. When compared with the long-term mean annual flow it has been estimated to represent less than 10% of this mean flow[25].

There are wide variations in not only the hydrology and climatic characteristics but also in the current level of use and dependence on the River. The high potential for energy production within the basin is relatively untapped and in many parts, irrigated agriculture has yet to realise its full potential. Pressure on land within the basin varies and although countries like Egypt have large areas, much of this is unsuitable for agriculture with the population concentrated in about 5% of the country. Both Rwanda and Burundi have severe pressure on their land resources, with average densities of around 300 persons/km^2 and localised areas where it will range from 400-500 persons/km^2. The largest country in the Nile Basin is Sudan[26] (Table 2.2) with water abstraction for agriculture being second only to Egypt (Table 2.3). Ethiopia has probably the largest cultivated area but has failed to realise the possible potential due to inadequate investments in the past, and the difficult terrain in the country. Burundi, Ethiopia, Rwanda and Uganda contain the largest proportions of people living within the rural areas of the Nile Basin exceeding 80% (Table 2.1) yet have difficulty in sustaining their livelihoods from agriculture. Kenya and Tanzania have slightly less people living and dependant on agriculture in rural areas, reflecting the trend in diversification away from agriculture to industries and services.

Table 2.2 Proportion of NBI Countries in Nile Basin

Basin	Country	Population million (2006)	GDP/Cap, US$ (2005)	Country Area (1000 km2)	% of the country in the Nile Basin	% of the total Nile Basin
1	Burundi	8.09	700	28	47.6	0.4
2	DRC	62.7	700	2,345	0.9	0.7
3	Egypt	78.9	3900	1,001	32.6	10.5
4	Ethiopia	74.8	900	1,127	32.4	11.7
5	Kenya	29	350	582	7.9	1.5
6	Rwanda	8.6	1500	26	75.5	0.6
7	Sudan	41.2	2100	2,506	79.0	63.6
8	Tanzania	31	220	945	8.9	2.7
9	Uganda	20	310	236	98.0	7.4

Source: FAO; Aquastat; 2005.

Environmental degradation, high population growth and unstable political condition are overarching issues in the basin. Theses challenges pose significant threats for food security and the social welfare of the Nile inhabitants. The control of the Nile has been a strategic objective across much of the basin for centuries. Joint cooperation and development in the basin had been constrained by potential and de facto conflicts arising from disagreements as to the supervision and management of the Nile water resources, which were inherited from

[24] All Nile basin countries except Eritrea are represented in the Nile Basin Initiative.
[25] FAO, 2005.
[26] The next largest country is DRC, however, only a small part of the country (23,000 km^2) drains into the Nile.

the colonial powers. However, all riparian states depend - though with varying degree of reliance - on the Nile waters for their needs, and/or have high expectations of harnessing Nile waters for their development.

Egypt, Sudan and Ethiopia are highly dependent upon water for agriculture (>90%) but only the first two use more than 5% of the annual water available in the Nile[27] (Table 2.3). Agriculture is by far the largest user of water, with most countries using more than 80% of the available water in the country. Uganda and DRC have relatively high and reasonably well distributed rainfall for crop production (Figure 2.2) and this account for the lower dependence on irrigation with infrastructure less well developed[28]. In Rwanda, there is limited scope for large scale irrigation development and although past plans were disrupted by past conflicts, considerable efforts are now being made to develop small scale irrigation and water harvesting.

Issue/Constraint: *Almost all of Uganda is located within the Nile basin and thus once the country starts to realise its full potential, estimated from between 90,000 ha (FAO-Aquastat) to 296,300 ha (Uganda Water development Department, 1970) this may have an impact on the downstream releases of water to the Nile.*

Table 2.3 **Total Withdrawals (According to FAO)**

COUNTRY	YEAR	ANNUAL WATER WITHDRAWAL million m3							
	(of data)	AGRICULTURE		URBAN USE		INDUSTRY		TOTAL	
		Volume	% of total	Volume	% of total	Volume	% of total	Volume	% of basin
Burundi	2000	222	77%	49	17%	17	6%	288	0.25%
Rwanda	2000	102	68%	36	24%	12	8%	150	0.13%
Tanzania	2002	4632	89%	527	10%	25	0%	5184	4.44%
Kenya	2003	2165	79%	470	17%	100	4%	2735	2.34%
Uganda	2002	120	40%	134	45%	46	15%	300	0.26%
DRC	2000	112	31%	186	52%	58	16%	356	0.30%
Ethiopia	2002	5204	94%	333	6%	21	0%	5558	4.76%
Eritrea	2004	550	95%	31	5%	1	0%	582	0.50%
Sudan	2000	36069	97%	987	3%	258	1%	37314	31.95%
Egypt	2000	59000	92%	5300	8%	4	0%	64304	55.07%
TOTAL								116771	

Source: FAO; Aquastat; 2005.

Agriculture is the largest employer in all Nile Basin countries, either directly or indirectly, although Egypt with its long history of agricultural development has succeeded in diversifying away from it, with only 31% of the economically active population engaged in agriculture[29]. The highest GDP per capita are found in Egypt and Sudan and surprisingly Rwanda[30]. Only Egypt stands out amongst the Nile Basin countries as providing reasonable services and quality of life, in general terms, to its inhabitants. However, it has the advantage that most of the population live in the narrow band of land along the Nile and in the Delta area, and that the economy benefits from oil revenues. Tanzania, Kenya, Uganda and Ethiopia with their population spread widely over large rural areas with often extremely undulating and

[27] Although data should be available from the FAO Nile Basin project, it has yet to be released. FAO Aquastat data have thus been used.
[28] Developments have been affected by long term instability in some parts of the countries. Rainfall distribution and amounts in Uganda have changed in the last decade resulted in a greater need and importance for irrigation.
[29] See Annexes A to I for detailed descriptions of the situation in each country.
[30] Rwanda has benefited from the return of experienced civil servants and businessmen following the establishment of relatively stable conditions and investments by government and the private sector.

inaccessible terrain, are considerably restricted in their efforts to reach all rural communities. Access to drinking water supplies is far better in urban than rural areas (+20% more people have access), but in both Ethiopia and Sudan, many people spend considerably time collecting water with Ethiopia reported to have only 11% of rural people with access to safe drinking water[31]. Efforts are being made by all countries to improve the situation under the Millennium Goals; however, these are often upset by internal conflicts, changing governments and impacts of severe weather conditions, whose frequency is increasing with global warming.

2.3 Climate

Despite being endowed with extraordinary natural resources, and a rich cultural history, the inhabitants of the Nile Basin face considerable challenges. The region is considered as one of the poorest in the world with more than 70% depending directly or indirectly on farming for their incomes and livelihoods. Water scarcity is a major challenge for the already closed basin. This is further exacerbated by incidence of climate variability and natural shocks such as droughts and floods.

Very Low Precipitation

High Precipitation

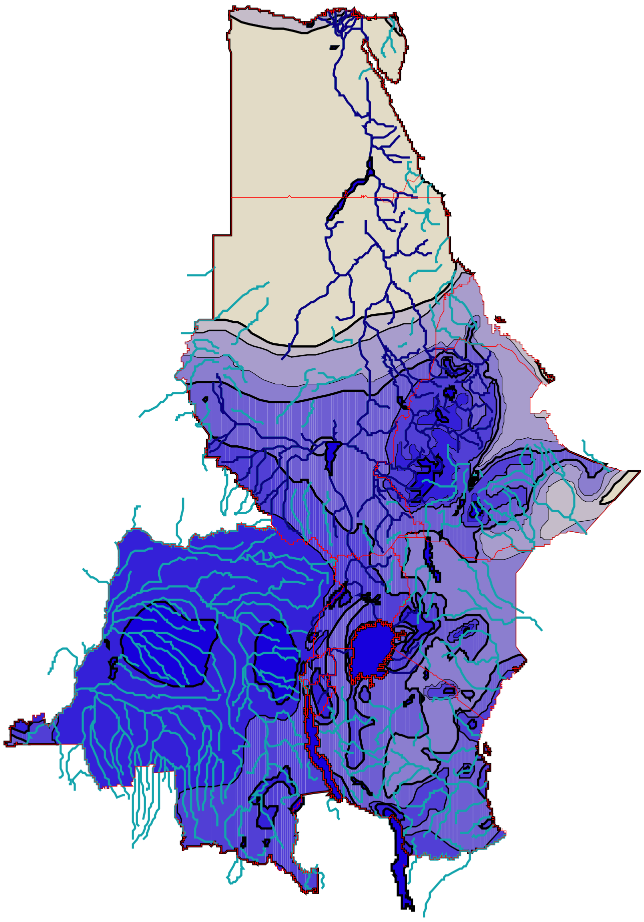


Figure 2.2 **Rainfall Distribution Across the Nile Basin**

Source: FAO.

[31] In the 1980's, Ethiopia embarked upon its programme of villagisation to try and address the problem by grouping rural residents in larger more compact villages, but the militaristic approach did not succeed.

Rainfall, temperature and evaporation vary widely across the basin with conditions for year-round cultivation occurring in the North (Egypt and Sudan), and longer growing periods occurring at the higher altitudes in the southern and south Eastern parts of the basin with some places affected by frost. Although data on mean rainfall would indicate that most places within the basin receive sufficient rainfall for rainfed cultivation, these data mask the true variability of rainfall that often occurs in intense storms separated by significant intervals varying from more than 20 to 30 days. In general terms, the northern third of the Nile Basin, with the exception of the coastal margins of the main Nile, receives negligible rainfall. Further south in the Equatorial Lakes region, the rainy season usually has two distinct peaks, but variability in rainfall in recent years has meant that the short rains have been much lower than expected and often untimely in their arrival. This is particularly true in the southeast of the basin. Except for Ethiopia and DRC, the periods of lowest rainfall occur from mid November to mid-February followed by the rainy season from mid-February to the beginning of June (Figure 2.2).

Meteorological data collection has generally encountered a serious reduction in the last decades. A core network of meteorological stations is available in all countries except DR Congo[32]. The dense rain gauge networks have been reduced, sometimes drastically with detailed assessment of aerial precipitation only possible using satellite images and remote sensing techniques. Telemetry is hardly used in any of the Nile Basin countries. Local variations in climate are difficult to assess especially within mountainous and hilly areas (orographic effects) and information previously available for the preparation of detailed designs are no longer reliable or available. In some countries such as Kenya, Uganda and Ethiopia, operational networks are still relatively dense, but sufficient funds are not provided for regular data collection and processing (Table 2.4).

Issue/Constraint: *Data availability in the basin needs to be upgraded and updated to take account of the climate changes that have taken place over the last 20 years and that will continue to vary with climate change. If designs are to be improved, then the significant deterioration of hydrological and rainfall data collection must be addressed. The Decision Support System (DSS) Component of the Water Resources Planning and Management Project, NBI is setting the framework to address this problem, but data needs to be readily available for all practitioners in all NBI countries.*

Table 2.4 **Details of Data Collection in NBI Countries**

Country	Remarks
DR Congo	Hydrological data collection interrupted since many years
Rwanda	Hydrological data collection interruption during war and genocide, now available in the Ministry of Water and Mines.
Burundi	Many stations abandoned, rating curves not updated since the early 1990s
Kenya	Data collection was intensive until recently but has suffered from institutional changes
Tanzania	Network existing but with operational problems, data processing delayed (most available times series end in the 1990s, LV Hydromet project)
Uganda	Basic network is operational
Sudan	Many stations abandoned or in need for rehabilitation, few stations produce discharge data due to a lack of discharge measurements; information for Southern Sudan is not available but it is clear that most of the historical stations have ceased to operate
Ethiopia	Operational network is relatively dense, data collection and analysis activities strengthened by the River Basin Integrated Master Plan Studies
Egypt	Hydrological data collection means essentially monitoring of water releases at the different water control structures; this is done in a comprehensive manner and making use of a telemetry system
Source: *Needs Assessment and Conceptual Design of the Nile Basin Decision Support System Consultancy, Draft Inception Report, 1 October 2007.*	

[32] The actual situation in the Nile basin area of DR Congo and in Southern Sudan is not known but it is anticipated that data collection activities will be very limited or non existent due to insecurity.

The major farming systems of the region broadly correspond with the main agro-ecological zones[33], although local factors – particularly market access – create potential for more intensive farming or for diversification within these zones (Table 2.6). Although in the region as a whole, the arid and semi-arid zones cover 39% of the land area and the sub-humid and humid zones cover 54%, the share of agricultural population of these zones is 16% and 74% respectively. Currently, a large majority of communities depend on agriculture for their livelihoods, and are living in the higher potential sub humid and humid zones. With an increase in population pressure, this will and is changing with many people in different parts of the Nile Basin moving to the more marginal lands within the arid and semi arid areas where extensive poverty already exists.

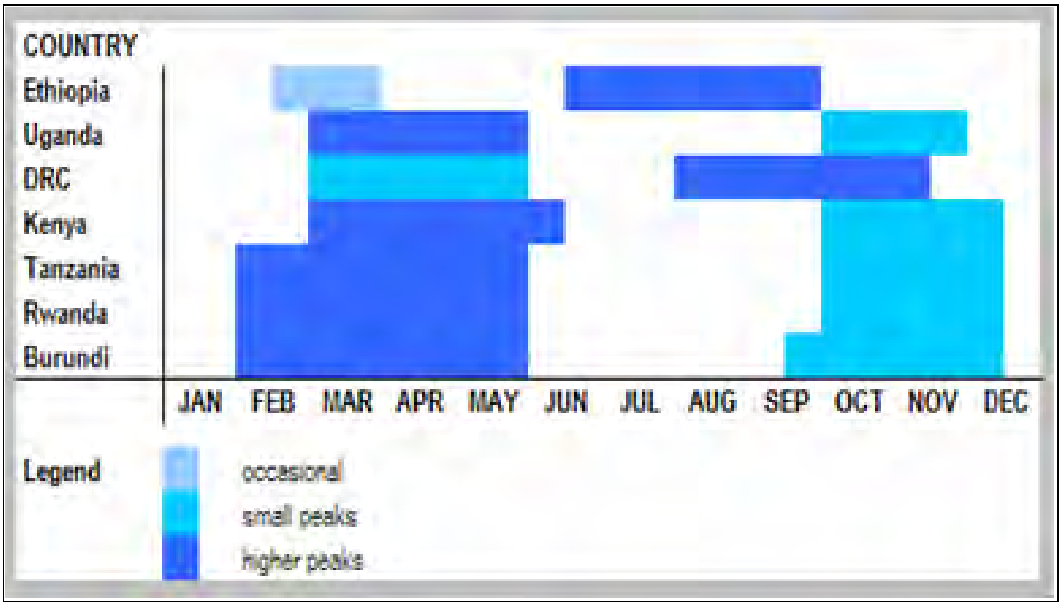


Figure 2.3 **Rainfall distribution in NBI countries**

Source: *Needs Assessment and Conceptual Design of the Nile Basin Decision Support System Consultancy, Draft Inception Report, Hydrophil GmbH, October 2007.*

2.4 Impacts of Climate Change

The last two decades have seen significant deviations from the longer term averages in terms of both rainfall and river flow. Under the NBI water management project, analysis of the Nile discharges since 1870 has shown a systematic decline to give and long-term annual average of 88 km^3/year[34]. Population increases and degradation of catchments have exacerbated the situation, and although experts are unable to agree upon future flows in the Nile, it is likely that without climate warming, the flows in the Nile Basin would increase by up to 10%. However, when climate changes are considered, it is probable that rainfall will become more intense and variable and temperature will increase significantly. This will result in a greater concentration of runoff giving declining base flows in the river and an increasing inability to meet peak agricultural water demands unless significant improvements are achieved over the next decade. Evapotranspiration is very sensitive to precipitation and temperature change, and will have particular significance in northern Sudan and Egypt where the Nile losses are relatively high and the crop water demands significant. Impacts will be widely felt as in food insecure areas such as the highlands of Ethiopia, food security will become an increasing issue.

[33] Agro-ecological zones are defined by FAO on the basis of average annual length of growing period for crops. For maps of farming systems and agro-ecological zones see http://www.fao.org/farmingsystems/mapstheme.htm

[34] ENTRO; (2006). Eastern Nile Planning Model Project Document, Eastern Nile Technical Regional Office, Final, Riverside Technology, inc., October 2006.

Along the various lakes, such as Lake Victoria in Uganda, Kenya and Tanzania, where extensive cultivation is taking place near to the lake shores, rises in lake level will have serious impacts and increase development costs due to higher drainage requirements. In Egypt, lower flows will impact on salinity and sea water intrusion and higher peaks floods will mean higher levels of siltation and changes to the operational rules of the dams.

Climate change will result in an increase in desertification[35] especially in Sudan that already suffers in 13 states out of 25[36]. The area currently affected extends from east to west and has increased from 205,000 Km^2 in 1958 to more than 340,000 Km^2 in 1982 (a rate of 8 km^2/an.)[37]. With population increases and climate changes, people living in already marginal areas have moved south in search of wetter lands. This has added more pressure on resources, creating significant demographic changes and serious conflicts and further accelerating desertification and land degradation. The compounding desertification processes are difficult to separate and quantify on the ground:

- **Climate based conversion of land types from semi-desert to desert**. The scale of rainfall reduction has changed the natural environment, irrespective of human influence. Less drought vegetation gradually fails to reproduce resulting in low vegetation density as observed in North Kordufan and North Darfur.
- **Degradation of existing desert environments**. At least 29% of Sudan is already true desert. Within this area, hundreds of smaller wetter regions exist resulting from localized rainfall catchments. These are already moderately to severely degraded.
- **Conversion of land types from semi-desert to desert by human action**. Over-exploitation of semi-desert environment through deforestation, overgrazing and cultivation results in habitat conversion into desert, even though rainfall may still be sufficient to support semi-desert vegetation. Conversion of dry land and fragile rangelands into traditional and dry land farming accelerated desertification.

Issue/Constraint: *Desertification is a serious problem facing Sudan that is causing a deterioration of land and reduces its potential capacity agriculture, ranges and forests. Introduction of water harvesting techniques and measures are essential for controlling this changing environment.*

[35] Defined as "The deterioration of land in arid and semi-arid regions as a result of different factors including climate change and human activities"
[36] Based on the evaluation of the Desertification Control Unit (1999).
[37] UNEP; 2006

Table 2.5 Details of Nine NBI Countries

Details	1	2	4	5	3	6	7	8	9
	Burundi	**DRC**	**Egypt**	**Ethioipa**	**Kenya**	**Rwanda,**	**Sudan**	**Tanzania**	**Uganda**
Physical areas									
Area of the country (ha)	2,783,400	234,486,000	100,145,000	110,430,000	58,037,000	2,634,000	250,581,000	94,509,000	24,104,000
Cultivated area (arable land and area under permanent crops) (ha)	1,351,000	7,800,000	3,422,178	10,671,000	5,162,000	1,385,000	16,653,000	5,100,000	7,200,000
• as % of the total area of the country	49	3	3	10	9	53	7	5	30
• arable land (annual crops + temp fallow + temp. meadows)	986,000	6,700,000	2,778,872	9,936,000	4,600,000	1,116,000	16,233,000	4,000,000	5,100,000
•area under permanent crops	365,000	1,100,000	643,306	735,000	562,000	269,000	420,000	1,100,000	2,100,000
Population									
Total population (inhabitants)	7,068,000	54,417,000	73,390,000	72,420,000	32,420,000	8,481,000	34,333,000	37,671,000	26,699,000
• of which rural (%)	90	68	58	84	59	80	60	63	88
Population density (inhabitants/km^2)	254	23	73	66	56	322	14	40	111
Economically active population (inhabitants)	3,739,000	22,644,000	27,902,000	31,683,000	17,078,000	4,512,000	13,806,000	19,337,000	12,743,000
• as % of total population	53.0	42.0	38.0	44.0	53.0	53.0	40.0	51.0	48.0
• female	49.0	43.0	33.0	42.0	47.0	51.0	30.0	49.0	48.0
• male	51.0	57.0	67.0	58.0	53.0	49.0	70.0	51.0	52.0
Population economically active in agriculture (inhabitants)	3,355,000	13,880,000	8,594,000	25,553,000	12,570,000	4,067,000	7,925,000	15,214,000	9,953,000
• as % of total economically active population	90.0	61.0	31.0	81.0	74.0	90.0	57.0	79.0	78.0
• female	53.0	53.0	49.0	40.0	50.0	55.0	38.0	54.0	50.0
• male	47.0	47.0	51.0	60.0	50.0	45.0	62.0	46.0	50.0
Access to improved drinking water sources									
Total population (%)	79.0	46.0	98.0	22.0	62.0	73.0	69.0	73.0	56.0
Urban population (%)	90.0	83.0	100.0	81.0	89.0	92.0	78.0	92.0	87.0
Rural population (%)	78.0	29.0	97.0	11.0	46.0	69.0	64.0	62.0	52.0

Notes:

1/. Based on Aquastat data from FAO

2/. Year of data varies from 2000 to 2005

3/. Once Data from the FAO Nile Project becomes available, it will be possible to update the data in the table

4/. Definitions used have been standardised by FAO Aquastat.

Table 2.6 **Agro-Ecological Zones and Major Farming Systems of Sub-Saharan Africa**

Agro-Ecological Zone	Length of Growing Period (days)	Major Farming Systems	Share of Land Area (%)	Share of Agricultural Population (%)	Principal Livelihoods	Prevalence of Poverty
Arid and semi-arid	<120	Sparse Agriculture (Arid)	17	1	Irrigated maize, vegetables, date palms, cattle, off-farm work	Extensive
		Pastoral	14	7	Cattle, camels, sheep, goats, remittances	Extensive
		Agro-Pastoral Millet/Sorghum	8	8	Sorghum, pearl millet, pulses, sesame, livestock, poultry, off-farm work	Extensive
Subtotal			**39**	**16**		
Dry subhumid	120-179	Maize-Mixed	10	15	Maize, tobacco, cotton, cattle, goats, poultry, off-farm work	Moderate
Subtotal			**10**	**15**		
Moist subhumid and humid	>180	Coastal Artisanal Fishing	2	3	Marine fish, coconuts, cashew, banana, yams, fruit, goats, poultry, off-farm work	Moderate
		Cereal Root-Crop Mixed	13	15	Maize, sorghum, millet, cassava, yams, legumes, cattle	Limited
		Root Crop	11	11	Yams, cassava, legumes, off-farm work	Limited-moderate
		Highland Temperate Mixed	2	7	Wheat, barley, tef, peas, lentils, rape, potatoes, livestock, poultry, off-farm work	Moderate-extensive
		Highland Perennial	1	8	Banana, plantain, enset, coffee, cassava, sweet potato, beabs, cereals, livestock, poultry, off-farm work	Extensive
		Rice-Tree Crop	1	2	Rice, banana, coffee, maize, cassava, legumes, livestock, off-farm work	Moderate
		Forest Based	11	7	Cassava, maize, beans, cocoyams	Extensive
		Tree Crop	3	6	Cocoa, coffee, oilpalm, ribber, yams, maize, off-farm work	Limited-moderate
Subtotal			**44**	**59**		
Total			**93**	**90**		

Note: Balance of land area and agricultural population accounted for by Urban Based, Large Commercial and Irrigated systems
Source: Dixon et al 2001

2.5 Overview of Water Resources and Availability

The Nile Basin is complex with water discharge at any given point along the main river course depending on many factors including weather, diversions, evaporation/evapotranspiration and groundwater flow. It receives water from two major sources: the equatorial lakes plateau with its year round rains (White Nile) and the Ethiopian plateau with its summer rains (Blue Nile). The latter contributes about 86% of the total Nile discharge (EL Daw, 2003), but its flow varies considerably over its yearly cycle and is responsible for large natural variation in flows. The flow contribution from equatorial lakes is 14%. During flooding (July to October) over 90% of the Nile River flow is from Ethiopia and less than 10% from Equatorial lakes. The low contribution of the Equatorial lakes basin to the Nile is attributed to water loss by evaporation in the swamps (Sudd), while the Ethiopian plateau with its steep slopes drains effectively into the River Nile. Most of the rivers flows occur during July to October (Table 2.7) with the characteristics of the Nile system tributaries being discussed below. Flows in the main Nile north of Aswan high Dam are governed by the dam operating rules and return flows that increase in downstream direction. Before the placement of dams on the Nile river, the yearly discharge varied by a factor of 15 at Aswan.

Peak flows of over 8,212 m³/s were recorded during late August and early September and minimum flows of about 552 m³/s in late April/early May. Although upstream dams now regulate the river flow, during the dry season the natural discharge of the Blue Nile can still be as low as 113 m³/s with typically no flow from the Atbara River; the last significant Nile tributary. During the wet season, the peak flow of the Blue Nile will exceed 5,700 m³/s in late August (variation by a factor of 50). From January to June the White Nile contributes 70-90% of the total Nile discharge.

Table 2.7 **Seasonal and total flows of the Nile River and Tributaries (1913-1989) (MM^3)**

River	July-Oct	Total Discharge
Main Nile at Aswan	57,396	83,953
Blue Nile	40,506	48,312
Atbara	12,023	12,466
Malakal	12,087	29,796
Sobat (White Nile)	6,454	13,298
Rahad & Dinder	3,761	3.761

Source: Compiled from FAO and Sutcliffe, J.V. The hydrology of the Nile. 1999.

• *The Blue Nile:* The flow of the Blue Nile reflects the seasonality of rainfall over the Ethiopian highlands, where the two flow periods are distinct. The flood period or wet season extends from July to October, with the maximum in August-September, and low flow or dry season from November to June. Therefore the annual Blue Nile hydrograph has a constant bell-shaped pattern, regardless of variation in the annual flow volumes. The average annual flow of the Blue Nile and its tributaries upstream of the confluence with the White Nile at Khartoum is about 50 km^3; the daily flow fluctuates between 10 million m^3 in April to 500 million m^3 in August (ratio of 1:50).

• *The White Nile:* Due to losses in the Sudd swamp area, the White Nile leaves this area with only about 16 km^3, out of 37 km^3 on entering it. The river receives about 13 km^3 from the Sobat River before joining the Blue Nile at Khartoum. The contribution of the Bahr el Ghazal basin is negligible, estimated at about 0.5 km^3. The average annual flow of the White Nile System at Malakal is about 29.5 km^3 and the daily discharge fluctuates between 50 million m^3 in April to 110 million m^3 in November (ratio 1:2). During the flood period the Blue Nile forms a natural dam that obstructs the flow of the White Nile and consequently floods the area upstream of the confluence.

• *The Atbara River:* This is a highly seasonal river, with an annual flow upstream of its confluence with the Nile of about 10 km^3 restricted to the flood period of July-October, the maximum occurring between August-September. The river has a steep slope and small catchments, and reflects the rainfall over the upper catchments as runoff at Sudan border within one to two days.

• *The Main Nile:* The reach of the Nile downstream of the confluence of the Blue and White Nile Rivers is known as the Main Nile. The Atbara River is regarded as the only and last tributary joining the Main Nile. The average annual flow of the Main Nile at the Sudan-Egypt border at Aswan is estimated at 84 km^3. The average annual yield of non−nilotic streams is estimated at about 7 km^3/an, of which 5 km^3/an are internally produced. Major streams exist in the east of the country (Gash and Barka), both of which are characterized by large variations in annual flow and heavy silt loads. The major groundwater formations and basins are the Nubian Sandstone Basin and the Umm Rwaba Basins. The Chazal, Sobat and Sudd swamps in the south represent major wetlands from which evaporation is exceptionally high, with the Sudd's extent estimated (1980) at over 16,200 km^2.

Water Measurement: During the period of declining water sources, there has also been a reduction in the support and funding of water measurement both at river and scheme level. In the past, many Nile Basin countries had a comprehensive measuring network. However, as sufficient funds have not been provided for the regular collection and processing of the data from all stations, many important but often remote (from the country's capital) stations have not been contributing with either many gaps being evident, or complete closure of the station taking place. Water measurement is an essential part of water sources management at catchment level and also in the improvement in water use efficiency by the users. Strategic water measurement is needed within all sub-basins, with all irrigation schemes having adequate measurement at the point where water leaves a river course towards the irrigated area. Below this point, water will usually be in control of the community or farmers groups and water measurement can be based on cropped area and crops grown, with the community itself ensuring equitable distribution and payment for the water received.

Water quality and sediment transport are monitored sporadically in most Nile Basin countries. Information on water use needs to be collected from individual sub-sector stakeholders. The statistics available often refer to production data (e.g. energy produced) or area data (irrigated area) rather than to actual water use, with conversions being not necessarily straightforward. Under the Nile Basin Initiative Water Resources Planning and Management Project, details of the flow between some basins within the Nile will be assessed. This project will determine the availability of water within each country and set this in the context of demands and potential within each country. These data are not yet available, but a preliminary assessment of the extent of irrigation development would indicate that the countries that are the greater contributors to the Nile flow also contain the least amount of developed irrigated agriculture. This is partly due to difficult terrain in some parts of the basin, but also to insufficient investment and expertise in the past to develop these areas. General details of the renewable resources of nine NBI countries (Table 2.8) show that there is limited recorded use of water in countries other than Egypt and Sudan. This does not mean that data are not collected, but that a more coordinated and integrated approach is necessary to include all users, particularly as peri-urban agriculture is becoming increasingly important in major towns and cities of the Nile Basin. To use treated portable water for agriculture is an inappropriate use of resources, particularly when up to 20% of urban populations are currently not supplied with portable water (Table 2.5).

Table 2.8 Details of Renewable Water Resources for the NBI Countries

Details of Water: Sources and Use	1 Burundi	2 DRC	4 Egypt	5 Ethiopia	3 Kenya	6 Rwanda	7 Sudan	8 Tanzania	9 Uganda
Renewable water resources									
Average precipitation (mm/yr)	1,274	1,534	51	848	630	1,212	416	1,071	1,180
(10^9 m3/yr)	35	3,618	51	936	366	32	1,042	1,012	284
Internal renewable water resources (10^9 m^3/yr)	10	900	2	122	20.7	10	30	84	39
Total actual renewable water resources (10^9 m^3/yr)	13	1,283	58	122	30.7	10	65	93	66
Dependency ratio (%)	19.8	29.9	97.0	0.0	32.6	0.0	76.9	9.7	40.9
Total actual renewable water resources/inhabitant (m^3/yr)	1,774	23,577	794	1,685	947	1,120	1,879	2,469	2,472
Total dam capacity (10^6 m^3)			169,000	3,458	4,079		8,730	4,196	1
Water withdrawal									
Total water withdrawal (10^6 m^3/yr)	288	356	68,300	5,558	2,735	150	37,314	5,184	300
- irrigation + livestock (10^6 m^3/yr)	222	112	59,000	5,204	2,165	102	36,069	4,632	120
- domestic (10^6 m^3/yr)	49.0	186.0	5,300.0	333.0	470.0	36.0	987.0	527.0	134.0
- industry (10^6 m^3/yr	17.0	58.0	4,000.0	21.0	100.0	12.0	258.0	25.0	46.0
• per inhabitant - m^3/yr	46.0	7.0	1,008.0	81.0	87.0	19.0	1,187.0	143.0	12.0
• as % of total actual renewable water resources	2.3	0.03	117.0	4.6	8.9	1.6	58.0	5.6	0.4
Non-conventional sources of water									
Produced wastewater (10^6 m^3/yr)			3,760		-				
Treated wastewater (10^6 m^3/yr)			2,971	0	-				

Reused treated wastewater (10^6 m^3/yr)			2,971	0	-				
Desalinated water produced (10^6 m^3/yr)			100	0	-		0.4		
Reused agricultural drainage water (incl. Seepage to GW) (10^6 m^3/yr)			10,967		-				
Use of fossil water (10^6 m^3/yr)			825						
Notes:									
1/.	Based on Aquastat data from FAO								
2/.	Year of data varies from 2000 to 2005								
3/.	Once Data from the FAO Nile Project becomes available, it will be possible to update the data in the table								
4/.	Definitions used have been standardized by FAO Aquastat.								
5/.	Average precipitation: Long-term double average over space & time of precipitation falling on country in a year, expressed in depth (mm/year) or in volume (km^3/year or $10^9 m^3$/year).								

Groundwater development is on the increase for both rural and urban domestic water supply, particularly in regions where this is the only available resource. Studies carried out by ENTRO indicate that most rural populations, who account for approximately 80% of the population in the Nile Basin, rely on groundwater for domestic water supply. It is widely used to meet their own needs as well as in the watering of livestock. In the upper part of the basin, particularly in Rwanda and Burundi, groundwater is widely exploited to meet both rural and urban water supply as well as sanitation. Some success has been achieved using solar power and if security and maintenance responsibility problems can be overcome, this has much wider application within the more arid and remote areas of the basin. Throughout the basin, significant supplies of groundwater exist but are only extensively utilised for agricultural production in Sudan and Egypt. Potential for expansion exists but energy costs will limit the use for agricultural production, except for high value crops, with most groundwater resources being used conjunctively with surface water. Potential also exists for using groundwater for drought mitigation, but this requires careful assessment and planning as most of the vulnerable groups in the susceptible areas of the basin are agro-pastoralists and have shown an inability/unwillingness to meet either the capital or recurrent costs.

Demand for groundwater is expected to increase drastically in the short and medium term as the countries strive to achieve the millennium goal of water supply for all by year 2025. Adequate replenishment of groundwater is essential for maintaining the environment mainly through sustaining base flows in streams and rivers. Recharge of groundwater derives from catchment management, natural drainage and wetlands, with contributions made from storage dams and other water retention structures. Changing land use and cover throughout the upper parts of the Nile Basin, mainly due to population pressure on better arable lands and a migration to the more marginal arable lands, has showed a significant decline over the last 1-2 decades, in base flows in surface streams. This has resulted in a lower availability of water for irrigation and increased development of wetlands that has already impacted negatively on groundwater recharge.

Much of the groundwater potential in the countries within the upper Nile Basin is site specific and thus good data are needed on the existence, extent, and availability before wider use can be promoted. Regular groundwater monitoring programmes are operational in Kenya, Uganda (low network density), Egypt and Ethiopia (a Groundwater Resources Assessment Programme has recently been started). In the other countries, groundwater levels are not monitored on a regular basis relying on data collected during project studies and borehole drilling campaigns related not only to irrigation, but also mining and potable water supply. Where hydro-geological data are available, they are often not analysed or interpreted in a systematic way and scattered across various organisations as in most cases, no dedicated service exists with studies and data being handled by the relevant institution. Therefore, there is insufficient information exchange between the interested institutions especially with those responsible for water resources management. An exception is Kenya and Tanzania where Water Resources Management Authorities have been established at the basin level.

Droughts and floods are symptomatic of many of the Nile Basin countries, especially where insufficient storage exists[38]. Sudan and Ethiopia have experienced many devastating spells of droughts and floods during the last two to three decades, with the worse damage occurring after the succession of dry years from 1978 to 1987. Drought is a major problem in western and northern Sudan, in northern Ethiopia and within the semiarid parts of the Nile Basin. Impacts from severe droughts can permanently change the whole pattern of rural life, including many human and livestock fatalities and the large-scale resettlement of people (close to three million people were moved in Sudan in late 1980s close to the Nile and in urban areas). Climate change and population pressures intensify the impact of droughts that disrupt social and economic life, aggravating environmental degradation and threatening the sustainability of the fragile ecosystem. Within the basin, these problems are increasing due to a trend towards reduced rainfall and desert creep form the Sahara. On other hand, drought benefits (if any) include raising the awareness of the stakeholder and removing harmful weeds and insects. Floods also impact heavily on the rural population causing loss of property, damage to infrastructure, irrigation facilities and water services and increasing the spread of water related diseases. National efforts and regional cooperation are required to establish national and regional early warning systems, public preparedness and other disaster management measures.

2.5.1 Water Agreements and Allocations

The first Nile Waters Agreement between Egypt and Sudan was signed in 1929. It allocated to Egypt the right to use 48 km^3/an, while it gave Sudan the right to tap only about 4 km^3/an. The treaty does not allocate any rights to Ethiopia to use the Nile waters and still binds Uganda, the United Republic of Tanzania and Kenya and bars them from using the Lake Victoria waters. In 1959, the Nile Waters Agreement was signed between Egypt and Sudan and Egypt's share of the Nile flow was set at 55.5 km^3/an. The agreement was based on the average flow of the Nile during the 1900-1959 period, which was 84 km^3/an at Aswan. Average annual evaporation and other losses from the Aswan High Dam and reservoir (Lake Nasser) were estimated at 10 km^3/an, leaving a net usable flow of 74 km^3/an, of which 18.5 km^3/an was allocated to Sudan. As the Nile riparian countries gained independence from colonial powers, riparian disputes became international and consequently more contentious, particularly between Egypt and Sudan. The core question of historic versus sovereign water rights is complicated by the question of where the river ought to best be controlled - upstream or down. To date, all riparian nations with the exception of Egypt and Sudan are still not included in this agreement, but in 1998, all countries (except Eritrea which has observer status only) joined in a dialogue under the Nile Basin Initiative (NBI) to review the treaty and allocation of water resources. Taking into account the past volatile relationships between the central actors, it is a significant achievement to get all basin countries together under the shared vision of NBI. This is a partnership initiated and led by the riparian states of the Nile River through the Council of Ministers of Water Affairs of Nile Basin states (Nile Council of Ministers, or Nile-COM).

NBI seeks to develop the river in a cooperative manner, share substantial socioeconomic benefits and promote regional peace and security. It started with a participatory process of dialogue among the riparian countries, that resulted in the shared vision to "achieve sustainable socioeconomic development through the equitable utilization of, and benefit from, the common Nile Basin water resources," and a Strategic Action Program to translate this vision into concrete activities and projects. As part of the interventions, NBI aims to

[38] The benefit of the Aswan High Dam was clearly seen in 1988 when high flood flows were effectively mitigated, with major damage occurring in Sudan (Khartoum) and other upper Nile Basin countries.

strengthen capacity to formulate and implement effective national policies and strategies for IWRM in Nile Basin countries and address the trans-boundary dimension within the national water policy process. It also aims to enhance the analytical capacity[39] for a basin wide perspective to support the development, management and protection of Nile water resources by providing a common, basin wide platform for communication, information management and analysis of Nile Basin water resources. A multidisciplinary framework for the design of transboundary solutions to the many challenges is being followed with a number of institutions taking part such as the Challenge Program on Water and Food led by Egypt's National Water Research Centre[40].

The transboundary nature of the Nile Basin presents formidable obstacles to sustainable resource use and national economic development to face rapidly increasing population, changing climate, widespread conflicts, environmental degradation and frequent natural disasters such as drought and famine, which all exacerbate water shortage. Unilateral management and control of each country's individual territory cannot, over the long term, benefit the region as a whole. Equitable and effective water allocation and environmental protection depend on institutionalized regional cooperation. Allocation of water resources, one of the most fundamental principles of the UN Watercourse Convention, thus remains the key issue facing the Nile Basin cooperation. This challenge is further complicated by riparian countries' decisions to implement development projects unilaterally. Such measures make future negotiations an even more difficult task and could undermine efforts to enhance cooperation in the Nile Basin. However, the other riparian countries that have not had the financial resources, or sometimes the need, to develop their full potential within their boundaries need to be included in discussions. Uganda for example, where almost all the country is located within the Nile Basin, has limited developed irrigation. However, to overcome recent water deficits, it intends to realise its full potential, estimated between 90,000 ha (FAO-Aquastat) to 296,300 ha (Uganda Water development Department, 1970). This will have an impact on downstream releases to the Nile. In the short term, Uganda estimates that its water requirements for agriculture, which includes crops, irrigation, wildlife, and aquaculture, will rise by about 50% giving an annual water requirement of 345 million m^3 (data in Table 2.8 only include water for crops and irrigation). However, this increase only represents about 0.25% of the water currently used for agriculture by Sudan and Egypt combined.

Climate change (Section) affects the stability of water allocation agreements and stability decreases when water becomes scarcer particularly in arid regions[41]. The precise effect depends on (i) river basin characteristics: its hydrological regime and the effects of climate change on river flow, and (ii) the agreement characteristics: in particular the sharing rule, the type of non-water transfers, the countries' benefit functions and the distribution of political power. Stability is affected by changes in both mean and variance of river flow, so both have to be taken into account when negotiating agreements on water allocation[42]. Besides economic gain, there are other issues that influence water allocation to riparian countries and the stability of cooperation. Acquired water rights can be an important determinant in river water allocation. A sharing rule based on acquired rights is not expected to be optimal from the view of efficiency and stability. Secondly, risk aversion might play a role as a country receiving a fixed allocation faces a lower risk of flow variability than a country that receives a

[39] Includes technical tools, trained staff, and coordination mechanisms.
[40] National Water Research Centre, Ministry of Water Resource and Irrigation (NWRC), Fum Ismailia Canal, P. O. Box 74, Shoubra El-Kheima 13411, Egypt.
[41] Climate Change and the Stability of Water Allocation Agreements, Erik Ansink, Arjan Ruijs. Environmental Economics and Natural Resources Group, Wageningen University. 4 January 2008
[42] Mendelsohn R, Bennett LL (1997) Global warming and water management: water allocation and project evaluation. Clim Change 37(1):271–290

non-fixed allocation or a proportional allocation[43]. More risk-averse countries will prefer fixed allocations over proportional allocations. Two approaches could be used to decrease the risk associated with low flows and generate more stable agreements, both of which reduce the incentive to break an existing agreement. The first is to invest in reservoir capacity which, when managed properly, can provide a buffer in water supply, decreasing the dependency on river water in low flow years. The second is to extend water allocation agreements to include water trading as water markets can improve the efficiency of existing water allocations. EWUAP has an important role in both approaches.

2.5.2 Water Scarcity

Water scarcity comprises of either Physical Water Scarcity or Economic Water Scarcity[44]. Physical Water Scarcity is defined in terms of the magnitude of primary water supply (PWS) development with respect to potentially utilizable water resources (PUWR). The physical water scarce condition is reached if primary water supply of a country exceeds 60% of its PUWR. This means that even with the highest feasible efficiency and productivity, the PUWR of a country is not sufficient to meet the demand of agriculture, domestic and industrial sectors while satisfying its environmental needs. Only Egypt faces physical water scarcity in the short to medium future (2025). Countries in this category will have to transfer water from agriculture to other sectors and import food or invest in additional storage or desalinization plants. Economic Water Scarcity covers those water-scarce countries that have sufficient water resources to meet their additional PWS needs, but require increasing their PWS through additional storage and conveyance facilities by more than 25%. Most of these countries face severe problems related to financial and institutional capacity for development of PWS to those levels. Against these definitions, IWMI estimates that all riparian countries other than Egypt face or will face economic scarcity.

2.5.3 Water Policy

African countries are in various stages of reforming their water resources strategies. Many of the Nile Basin countries have either prepared a National Water Policy or are in the process of preparing them. Some have actually come to grips with the rather difficult issues involved and have concluded that integrated water management approach is needed with water demands assessed at basin level. This is not restricted to Africa alone, but in all emerging Nations changes in the approach to water management is being adopted. The broad objectives of these policies are to try and achieve equitable access to water and sustainable and efficient water use for optimum social and economic benefit. These require adequate legal framework and comprehensive provisions for the protection, utilisation, development, conservation, management and control of water resources. The strategies being developed present details on the way in which water resources will be managed and the implementation of the strategies is of major importance to irrigated agriculture. This is particularly true in the case of integrated water management for sustainable rural development. Although smallholder developments are not large consumers in the overall picture, the provision of access to water supplies for the poorer members of community engaged in subsistence agriculture is an extremely important part in the socio-economic transformation set out in the policies.

Part II: AGRICULTURAL WATER USE IN THE NILE BASIN

This section examines the situation relating to agriculture and water use in the Nile Basin countries and identifies issues, constraints, and opportunities arising (Section 3). Agriculture

[43] Bennett LL, Howe CW, Shope J (2000) The interstate river compact as a water allocation mechanism: efficiency aspects. Am J Agricult Econ 82(4):1006–1015
[44] International Water Management Institute (IWMI)

and Water Use in each of the Nile Basin countries has been established for each country (see Annexes A to I) based upon information provided in the Rapid Baseline Assessments[45], carried out by national consultants prior to the arrival of the international consultant. These have been supplemented with further data and information as no profiles existed for two countries and much relevant information was lacking from the reports. A number of national and international sources were used and the most important references appear in the footnotes to the text with the list included in Annex K. Issues of concern are highlighted in the text and derive from an analysis of the situation in each country (Annexes A to I). Commonalities that derive from these issues are presented in the context of efficient water use for agricultural production (Section 4) to establish the overall situation and needs within the Nile basin. Transboundary issues have been highlighted as these are of concern to all riparian states. In the time available, it is inevitable that some issues important to individual countries may have been understated, but it is considered that with the process of review before the finalisation of this report, the major issues and constraints have been highlighted. The information presented then leads onto Part V of the report where opportunities for addressing the issues raised are discussed to identify possible potential areas for NBI support under the Subsidiary Action Plans (SAPs).

.2 Agriculture and Water Use in the Nile basin countries

The problems of the Nile region are as interconnected as the basin's waterways - each flows into the next – with the use in one country being dependent on the actions in another. Among the most serious challenges are poverty and food insecurity, water shortages, land degradation and pollution from effluents. Deforestation and cultivation of steep slopes have led to heavy soil erosion, loss of biodiversity, and sedimentation of lakes and reservoirs. The Nile has also become seriously polluted by agro chemicals, untreated sewage and industrial waste. Literature on the Nile Basin and the use of its waters overwhelmingly concentrates on the three countries considered to be the central players of the Nile Basin namely Egypt, Sudan and Ethiopia. Although these countries can be considered the major players, the remaining riparian countries are becoming more important and are developing their resources for improved agricultural production. In the first agreements for the use and benefit of the Nile waters, they were excluded. However, as discussed in the previous section of this report, this needs to be addressed with all riparian countries involved in the determination of the future directions of the Nile basin and the use of its resources. This must include balancing the needs for more water in the most agriculturally developed countries with appropriate complimentary interventions including financing in the less agriculturally advanced countries.

As has been illustrated in section 2, agriculture is the greatest user of water within all Nile Basin countries (Table 2.8). It dominates in its contribution to GDP as well as towards the livelihoods of the population living within the basin. In all countries, it employs around 80% of the total population with over 70% of this rural population being engaged in agriculture. Summary data on the overall situation in each country (Table 3.1) are derived from the completed rapid baseline assessment reports (RBA) and show that rainfed agriculture represents by far the largest land use within the basins. Any consideration of improvement in water management within the basin must therefore deal with both irrigated and rainfed land in a parallel linked manner and not separately as has been the case with many donors and governments. Interventions and support must be linked to improving the amount of water retained within the rainfed areas and reducing the speed of runoff within all catchments as well as meeting the increasing water demands in the irrigated areas.

[45] All reports adopted a different approach to the assignment and data collected was not unified. Levels and quality of data and information available for each country varied considerably. No information was available for DRC as the area was insecure. It represents only a small part of the Nile Basin. Issues arising will be similar to those of Burundi and Rwanda.

Detailed data on water use and irrigated system performance is inadequate in all riparian states. No comprehensive information yet exists enabling an analysis and prioritisation to be developed based on needs rather than on the development fashion of the time. The FAO Nile project has spent almost ten years compiling data on all Nile Basin countries, but this is still not readily available to practitioners who need accurate information as the point of departure. Such information needs to be readily accessible by all as it is for the common good of developments in the Nile Basin.

Concern: *The Nile basin initiative countries need to identify areas of critical concern within their countries considering availability of water, utilisation of agricultural land and degree of degradation.*

2.1 Agriculture in the Nile Basin

A wide variety of crops are grown under irrigated and rainfed conditions within the Nile Basin. An overview of the irrigated crops in the Basin (Table 3.1) shows that detailed overall data is not readily available but that only 4 countries have significant areas under irrigation at the moment. In the lower part of the basin in Sudan and Egypt, all crops need to be cultivated with some form of moisture retention technique including irrigation. In general, yields are higher in these areas than the upper catchment of the basin, mainly due to the large-scale irrigation systems, the availability of better quality seeds and inputs (especially heavy fertilizer use – on average some ten times more in Egypt than Ethiopia) and reliable full irrigation. In Sudan, the situation is much more variable as infrastructure has been damaged by floods and other events, or has been disrupted by hostilities (in the south of the country) and outside the larger schemes support services sub-optimal. In the other riparian states, productivity has been less than should have been expected considering the levels of investments made. However, the situation has been complicated by periods of climate changes and insecurity in parts almost all of the countries. What is clear is that farmers are not receiving the advice and support that they need to improve their techniques and to raise production levels.

Table 3.1 A Comparative Overview of Irrigated Crops in the Nile Basin countries

Irrigated crops in full or partial control irrigation schemes	1	2	4	5	3	6	7	8	9
	Burundi	DRC	Egypt	Ethiopia	Kenya	Rwanda	Sudan	Tanzania	Uganda
Total irrigated grain production - tonnes	25,260		19,230,797	238,138					
as % of total grain production	10.0		100.0	2.6					
Total harvested irrigated cropped area - ha				410,557				227,000	
Annual crops: total - ha		13,500	3,773,462	395,016	13,229			227,000	
- rice - ha	4,210	2,300	650,026		14,533			89,000	1,650
- coffee - ha	500				172				
- tea - ha					350				
- sugar cane - ha	1,450	11,200	135,815	27,197	3,262				100
- flowers - ha			26,055		5,950				
- vegetables - ha	800		472,062	107,126				81,000	560
Permanent crops: total - ha			2,253,653	15,541					20
Irrigated cropping intensity - %			176	142				123	
Total drained area - ha		3,900	3,024,000		18,639		560,000		

- part of the area equipped for irrigation drained - ha			3,024,000						
drained area as % of cultivated area		0.1	88				3		
Area salinized by irrigation - ha			250,000				500,000	50,000	
Source: FAO – Aquastat									

2.1.1 Crop Production

Agricultural production is divided between commercial and private activities for export, and subsistence production for local consumption. Whether rainfed, irrigated or under some other form of agricultural water, agriculture is by far the most predominant economic activity in the Nile Basin. It ranges from largely rainfed subsistence agriculture to large irrigated estates, the latter of which are mainly found in Egypt and Sudan but also in some schemes in Ethiopia, Tanzania and Kenya. Many parts of the Nile Basin are able to produce food in sufficient quantities to meet their nutritional needs, but only about 75% of food demand. In 2000, it was expected that production would gradually increase and approach self sufficiency[46], but with high population growth over the last decade and the impact of very variable rainfall and recurrent droughts, this has not been achieved. Although there have been variations within the Nile Basin, productivity levels are still low with many of the Nile Basin countries dependent on importing a significant proportion of their food needs. The impact of this dependency on external crop production has been highlighted recently with a number of governments being unable to meet demands for wheat. This impacts mostly on the poor within the Nile Basin countries, as they are more vulnerable and less able to purchase the food they need due to price increases.

The primary staples in the eastern and lower Nile comprise wheat, millet and sorghum. In the southern Nile, roots and tubers form the primary staples, though maize is also heavily consumed in some areas. Although the lower parts of the Nile Basin are based on high inputs with large levels of fertiliser use, the remaining parts of the basin rely upon low-input, low-yield subsistence farming. The scope for increased crop production thus lies in increases within the existing cultivated irrigated areas where higher inputs can be successfully achieved with reliable irrigation supplies. There may be negative impacts on water quality deriving from this process, but these could have beneficial effects on the downstream users. Post-harvest management is often rudimentary with losses that can reach as much as 40%. There is thus considerable scope for augmenting crop production through improvements at farm and household level to both reduce losses as well as increasing the quality of the product. Agro-processing is an important area that is currently under supported not well developed in many of the upper part of the Nile Basin. This can provide added value to the crops as well as providing additional off farm employment and such improvements could catalyse economic activities in the agricultural sector.

Concern: *Examination of constraints to both rainfed and irrigated agriculture highlights the poor extension support in almost every country, the lack of availability of quality seeds and other inputs and the absence of readily available credit for small farmers to facilitate the timely purchase of inputs, especially fertilizer.*

2.1.2 Livestock Production

Throughout the Nile Basin, livestock is a crucial subsistence and economic activity and the Nile Basin is home to some of the largest populations of livestock in Africa with Ethiopia having the largest in Africa followed by Sudan. Although there is little hard information

[46] Water and Agriculture in the Nile Basin. NBI Report to ICCON. Appelgren et al. FAO. 2000.

concerning the sector's water consumption within the Nile Basin[47], provision of water for nomadic herds and agro-pastoralists is extremely important, especially in the semi arid areas of Egypt, Sudan, Ethiopia, Kenya, Tanzania and Uganda. Considerations of the needs of livestock and in particular watering thus form an important part of livestock policy within the Nile Basin. In spite of this, information on livestock water consumption and means of meeting demands is not comprehensively covered within the readily available data. Farmers are using a wide range of techniques for meeting these water demands, with traditional practices often resulting in large annual migrations towards limited perennial water sources [48]and the degradation of range lands during the dry seasons on these routes.

Issue/Constraint: *Livestock Productivity is constrained by Water Supply and also by insufficient suitable pastures throughout the year.*

Uganda has recognized the problem, and has located strategic supplies of livestock water within these traditional routes in an effort to prevent disruption to agriculture and conflict between the pastoralists and the agriculturalists. Many countries are pushing the need for small storage dams (called Haffir or valley tanks) to meet short-term needs of livestock. In general, supplies provided in this manner are usually sufficient for between three to six months depending upon local conditions. In times of drought and towards the end of the dry season, livestock will continue to migrate towards the limited perennial water supplies unless groundwater resources are tapped locally to meet livestock as well as human needs. Maintenance and payment for the water at these sites is a major constraint, as pastoral communities are unwilling to take responsibility for sources that they use seasonally and that are utilised by others.

Concern: I*n those Nile basin countries where sufficient provisions have not been made for livestock watering, degradation of grazing lands results from the annual search for water in the more arid regions of the counties as well as during the drought periods.*

Over much of the basin, livestock is regarded as a commodity in which funds are invested for later use. Livestock numbers are on the increase, particularly in central Sudan, where there has been a major reduction in total area due to desertification and land use changes. This has been exacerbated by widespread deterioration of range lands caused largely by drought climate change and overstocking but with contributions from uncontrolled burning (64% of the range changed from good to poor in less than two decades). More support is needed to improve the management of the rangelands, drinking water points and to improve resources (fire lines construction, enclosures, closing/opening technique, minimizing excessive browsing and grazing, with community involvement). The International Livestock Research Institute (ILRI)[49] in Ethiopia has produced generalised data from which livestock water demands can be estimated, and donors such as IFAD have been concentrating some of their efforts in this direction. Attention also needs to be paid to the rights and land use patterns of pastoralists in the Basin, as without a good understanding, irrigated developments can impinge upon traditional grazing lands giving rise to conflict as well as considerable hardships.

[47] According to some estimates typical TLU in the NB needs around 50 l/day for drinking purposes, this alone totals some 1.5 km^3/yr for just Ethiopia's and Sudan's livestock, and as much as 150 km^3/yr including grazing and fodder.
[48] This is particularly striking in Karamoja in Uganda, where transhumance is associated with cattle raiding in areas to the south.
[49] www.ilri.org

Issue/Concern: T*he absence of clear legislation and enforcement to protect range lands coupled with inadequate past policies and development planning, has resulted in the expansion of the agricultural sector at the expense of range and forest lands.*

2.1.3 Fisheries

Fish are an important source of nutrient for poor communities and are a very important economic activity for those living around the larger lakes within the Nile Basin[50]. Although they are not a significant consumer of water, provision has to be made for the harvesting of water for aquaculture. When combined with other forms of agriculture, they form a valuable part of the farming system. Even in those areas were sufficient runoff cannot be collected for annual cultivation of fish; there is scope for the enlargement of fingerlings during one season to be harvested for consumption and sale. Such developments are normally confined to the private sector being individually based. More support is required in this sector, as farmers who depend upon this for their living have raised significant problems of marketing, outside interference and unsustainable use of resources by those outsiders to the areas with commercial interests.

Issue/Constraint: *The identified constraints of aquiculture development include the lack of qualified technical supervisory staff, an insufficient demand for fish, the expensive construction of ponds, a lack of clearness as for the objectives of the interventions and inadequate legislation or enforcement of laws.*

2.2 Role of Irrigation and Water Harvesting

The climate change that has taken place since the 1990s has seen significant periods of marginal rainfall at times when secure precipitation was expected based on past experience. Undue reliance on the vagaries of rainfall has been shown to impact significantly on both the national economies and vulnerable smallholder farmers, with an overall decline in their assets and increasing food shortages for the rural poor and those living below the poverty line. Farmers can no longer rely on annual rainfall to provide good, reliable and regular crop production and are looking to both irrigation and water harvesting to reduce the risks of their endeavours.

The Nile is one of the nine largest basins in Africa and contains 19% of the irrigation potential of the continent amounting to about 8 million hectares. Although much of this has been developed in Egypt and Sudan, many of the Eastern African countries, such as Uganda, have only developed a small proportion (Table 3.2). Irrigation for agriculture is the dominant user of water, thus it is necessary to mitigate the seasonality and variability of rainfall. A useful indicator of water scarcity (or a lack thereof) is the extent of undeveloped irrigation potential. In other words, if the agricultural sector is a major user of water (usually for irrigation) and if irrigation is significantly underdeveloped, then scarcity is low, and vice-versa. Only Egypt and Sudan have developed significant amounts of irrigation potential (70%). Tanzania has developed about a third of its potential and although Ethiopia has significant areas of irrigation, many of the developed areas are not within the Nile Basin. Rwanda, Burundi, Kenya and Uganda have significantly smaller irrigation potential than the remaining riparian countries that have in general ten times more potential for development. From this it can be seen that there is a wide variation in data available. For example, spate irrigation is taking place in many of the Nile Basin countries, but as this is done on an informal basis, it is not well recorded or reported.

[50] In Tanzania - Lake Victoria, 80,000 fishermen caught fish worth some $100 million in 2002; Jebel Aulia Reservoir Sudan has 15,000 tonnes potential and Lake Nasser (80,000 tonnes potential).

Many constraints have prevented earlier development varying from insufficient funds, limited demand or need and prolonged periods of strife. The role of irrigation in the riparian countries has been recognised but is not the only solution, as, even if all of the irrigation potential was realised, only 10% of the currently cultivated land would benefit from irrigation. It is essential therefore that both irrigated and rainfed agriculture are supported in an integrated manner to firstly raise production levels for small scale farmers who depend upon the cultivation of basic food crops for survival, and secondly to increase crop availability in line with market demands. Irrigation and water harvesting techniques encompass a wide range of interventions that enhance productivity and reduce the impact of rainfall variability; hence enabling agricultural production to be practiced in areas that otherwise would not continue to support rainfed crop production.

When approached holistically, with equal levels of support for both the software and hardware aspects, it has major positive impacts at household and village level. For the substantial areas managed by smallholder farmers through traditional irrigation systems or water harvesting, it benefits the rural farming communities both directly and indirectly through improved food security, self-sufficiency and food production. In large-scale commercial farms, it enables crop production for local and export markets with significant impacts on the country's economy. When examined purely in investment terms, it seems that irrigation development requires high investments that benefit relatively few people. This ignores the substantial spin-off effects to the surrounding communities who not only become involved in direct and indirect activities, but who also benefit from the improved infrastructure facilities and supporting services. These benefits are much easier to quantify and monitor compared with rainfed extension services[51].

Table 3.2 **Irrigation Abstractions for Agriculture**

COUNTRY	use as % of total abstractions	potential within NB (ha)	area already irrigated in NB (ha)	% of potential
Burundi	77%	80,000	not known	not known
Rwanda	68%	150,000	2,000	1%
Tanzania	89%	30,000	10,000	33%
Kenya	79%	180,000	6,000	3%
DRC	31%	10,000	0	0%
Uganda	40%	202,000	9,120	5%
Ethiopia	94%	2,220,000	23,160	1%
Eritrea	95%	150,000	15,124	10%
Sudan/1/2	97%	2,750,000	1,935,200	70%
Egypt	86%	4,420,000	3,078,000	70%

Notes

1 not including the Sudd swamps

Source: *Hydrophil - consulting & knowledge development GmbH. October 2007*

Issue/Constraint: *Agriculture can contribute significantly to poverty reduction as it is the largest employer of labour - 80% of the poor are engaged in agricultural activities - and studies in Kenya have shown that, because of the value added and the consumption multiplier effect, agricultural growth actually accounts for 60% of the 5% growth rate in GDP.*

[51] As illustrated in the extension and research programmes of TARP and NAEP in Tanzania for example.

Recent support for irrigation has shown that with full beneficiary involvement, crop yields and returns can be significantly increased[52], provided that farmers are fully involved and that irrigation investments are not treated just as infrastructure investments. Where poorly performing developments exist, yields can be doubled or tripled within a relatively short period (three years from the first project interventions) provided that farmers are organised with good extension support and targeted investments are made to remove constraints in the water delivery systems. In Tanzania, the River Basin Management Smallholder Irrigation Investment Project (RBMSIIP) was successful in contributing significantly to food production and security[53] with the returns to labour varying from US$ 3 to US$ 5/day, thereby providing alternatives to casual off farm labour. Where perennial water sources are not available but water harvesting techniques are utilised[54], investments and returns will be lower but the security of water supply and production increases will still be sufficient to encourage farmers to participate in the developments and thereby remain in their home community areas.

2.3 Irrigation Developments

Performance from irrigation developments in Africa has not been as good as was expected. There have been many expensive failures, and much of this resulted from a poor understanding of the continued long term regular support needed to farmers, and the capacity of communities to manage the schemes. Many investments were treated as infrastructure building and the software aspects necessary for success were lacking. This led to an increased caution amongst donors and lending agencies in supporting irrigation developments with sector-wide approaches (SWAP) being adopted in some of the Nile Basin countries. This may have suited support for rainfed agriculture, but many areas with good potential for improvement of irrigation are not being addressed in a timely manner. Involvement by the private sector has also been small, mainly due to the poor enabling environment and limited understanding of policy-makers and stakeholders on the importance and role of irrigation.

Issue/Constraint: *Government should encourage the development of irrigated agriculture, particularly by communities and the private sector, including individual farmers and ensure a conducive environment for this process such as negotiating with banks to extend credits for irrigation development.*

2.3.1 Classification of Irrigation Development

The definition of scheme size varies between countries (Table 3.3). There is little consensus on what should be adopted and many definitions do not comprehend the increasing levels of complexity and management requirements. While certain countries such as Rwanda and Burundi consider a scheme with a command area of more than 100 ha as large, many others in the Nile Basin consider 100-200 ha as small scale. In Ethiopia, medium scale irrigation varies from 250-3000 ha. Kenya classifies schemes according to whether they are privately /commercially owned or whether they are run by government.

Table 3.3 Definition of Irrigation Scheme Size by Nile Basin Country

Definition of Irrigation Size	Burundi	DRC	Egypt	Ethiopia	Kenya	Rwanda	Sudan	Tanzania	Uganda
Small-scale schemes (smallholder)	<50	<100		<250	5 - 1,000		<100,000	<50	<50

[52] For example under the RBMSIIP project in Tanzania.
[53] Average family incomes in Tanzania have reflected the degree of farmer involvement, having risen from US$ 425 for the Pangani basin and US$ 340 for the Rufiji Basin to around US$ 1,500 and US$ 1,100 respectively.
[54] Such as with PIDP.

Medium-scale schemes	50 - 100	100 - 1,000		250-3000	0.5 - 5,950			50 - 500	50 - 500
Large-scale schemes	>100	>1,000		>3000	213 - 6,200		>500,000	>500	>500

Source: *FAO Aquastat. 2005.*

Egypt has large-scale irrigation schemes except water harvesting that are not included in this definition. Sudan regards any scheme with less than 100,000 ha as small. For this reason, the tendency has been to move away from describing or classifying schemes by size, but rather by management type. This complies with the move for greater community management and the IMT process. A useful classification separates schemes into private small farms, commercial farms (that need economy of scale but that are often small to medium in command area), community run schemes and public schemes.

2.3.2 Extent of development of Irrigated Agriculture in Nile Basin

Estimates of the extent of irrigation development within the Nile Basin countries prepared by FAO[55] (Table 3.4) do not give a clear idea of the developments within the Nile Basin, as the data are not disaggregated by Basin. Except for Uganda, where almost all of the country is contained within the Nile Basin, past investments for Upper riparian countries have been made mainly in other more accessible and priority basins. In the past, rainfall amounts in the Nile Basin have been generally sufficient to meet crop needs and it is only relatively recently that irrigation has been considered as needed in this areas. Changes in land use cover and cultivation within the upper catchment, coupled with climate change, has resulted in significant variations in water availability and run-off characteristics. In the eastern Nile region, particularly in Ethiopia and Eritrea, the incidence of droughts and severe floods has become more likely. Extreme floods and droughts have also been experienced in Uganda and Kenya as well as the water shortages within Rwanda and Burundi. These all serve to illustrate the changing environment for irrigation and the increasing needs and opportunities for expansion.

2.3.3 Community Managed Irrigation Schemes (CMI)

In all riparian countries, small-scale irrigation developments usually comprise of community managed schemes. These are made up of those schemes developed by the farmers/communities and those originally developed by governments, but which are now handed over to the communities for operation and maintenance. Very few schemes of this size are still run by governments. The handover has in many cases been too rapid without adequate follow up and training and the performance is thus varying across the basin. Furthermore, the situation in community managed irrigation schemes will also vary, depending on whether the scheme was initially developed by the communities or whether they were developed by government on their behalf. Traditional/informal irrigation schemes are generally working more effectively[56], but the condition of infrastructure is in most cases poorer than on the formal/modern irrigation systems. Water Users Associations on traditional schemes are run along traditional lines/practices, and are thus more cohesive and effective than the newer WUAs, provided that government/donor interventions have been sensitive. Where donors, government or NGOs have assisted communities to improve irrigation systems without properly understanding or recognising the traditional structure, unsustainable interventions and solutions beyond the capacity of farmers to operate and maintain within their own resources have resulted.

[55] Irrigation in Africa in Figures, Aquastat Survey, FAO, 2005.
[56] These schemes normally cover older schemes and comprise those developed by the community themselves using their own resources and no outside guidance. They often have good community management, but could be regarded as inefficient as they had been developed only through the technology and resources available to cash poor and resource poor societies.

Issue/Constraint: *Assessment of 100 irrigation schemes in Oromia region of Ethiopia (1999) showed that 17% of schemes had failed, 42% performed at less than 50% of capacity and 41% performed at greater than 50% capacity. Problems identified included insufficient collaboration between relevant government institutions, insufficient input supply, agricultural extension workers insufficiently qualified and equipped for the complex extension tasks (irrigation agronomy; soil fertility management; crop protection;) and water users associations inadequately trained to manage schemes in a technically, economically and socially sustainable way. (Annen, 2001).*

Issue/Constraint: *There is a lack of Extension technical capacity in agronomy & water management with agricultural extension workers insufficiently qualified and equipped for the complex extension tasks of irrigation and drainage system design and improvement, irrigation agronomy and water management.*

Water management on community irrigation schemes is one of the main areas for improvement. Where less control is exercised on water application, increased waterlogging and salinity have occurred. Improvements in water efficiency on these schemes will result in tail-end beneficiaries receiving more equitable amounts of water and greater flexibility in operation enabling cultivation of a wider range of crops. This will also free-up water to supply areas outside the original scheme command area to accommodate population growth within the community.

Table 3.4 A Comparative Overview of Irrigation in the Nile Basin Countries[57]

Details of Irrigation and drainage	1	2	4	5	3	6	7	8	9
	Burundi	**DRC**	**Egypt**	**Ethiopia**	**Kenya**	**Rwanda**	**Sudan**	**Tanzania**	**Uganda**
Irrigation potential (ha)	215,000	7,000,000	4,420,000	2,700,000	353,060	165,000	2,784,000	2,132,221	293,300
Water management									
1. Full or partial control irrigation: equipped area (ha)	6,960	10,000	3,422,178	289,530	103,203	3,500	1,730,970	184,330	10,848
- surface irrigation (ha)	6,960	10,000	3,028,853	283,163	39,217	3,500			10,618
- sprinkler irrigation (ha)	0		171,910	6,355	61,986				230
- localized irrigation (ha)	0		221,415	12	2,000				0
% of area irrigated from groundwater	0.0	0.0	11.0		1.0		4.0	0.2	
% of area irrigated from surface water	0	100	83		99		96	99.8	
2. Equipped lowlands (wetland, ivb, flood plains, mangroves) - ha	14,470	500				5,000			3,570
3. Spate irrigation - ha							132,030		
Total area equipped for irrigation (1+2+3) (ha)	**21,430**	**10,500**	**3,422,178**	**289,530**	**103,203**	**8,500**	**1,863,000**	**184,330**	**14,418**
as % of cultivated area	1.6	0.13	100.0	2.5	2.0	0.7	11.0	3.6	0.1
average % increase/year over last 11 yrs 1992-2003	2.7		0.6	6.2	4.1		-0.9	2.3	
power irrigated area as % of total area equipped			86		46		19	0.8	
% of total area equipped actually irrigated		70	100		94		43		65
4. Non-equipped cultivated wetlands and inland valley bottoms (ha)	83,000	2,000			6,415	94,000			49,780
5. Non-equipped flood recession cropping area – ha		1,000							
Total water-managed area (1+2+3+4+5) (ha)	**104,430**	**13,500**	**3,422,178**	**289,530**	**109,618**	**102,500**	**1,863,000**	**184,330**	**64,198**

[57] Data shown are for the whole country as basin specific data are not available. For potential and irrigated data for the Nile basin only, see Table 3.4

as % of cultivated area	7.9	0.17	100.0	2.5	2.1	8.9	11.0	3.6	0.8
Full or partial control irrigation schemes Criteria									
Small-scale schemes (smallholder) - *definition varies*	800	1,480		191,827	48,048		443,070	5,533	300
Medium-scale schemes - *definition varies*	500	220			42,700		417,150	71,212	2,036
Large-scale schemes - *definition varies*	5,660	8,300		97,703	12,458		870,750	107,243	12,082
Total number of households in irrigation -							200,000		
Notes:									

1/.	Based on Aquastat data from FAO with additional data added where available
2/.	Year of data varies from 2000 to 2005
3/.	Once Data from the FAO Nile Project becomes available, it will be possible to update the data in the table
4/.	Definitions used have been standardised by FAO Aquastat.
5/.	Average precipitation: Long-term double average over space & time of precipitation falling on country in a year, expressed in depth (mm/year) or in volume (km^3/year or $10^9 m^3$/year).
6/.	Medium-scale schemes in Kenya relates to Private/commercial schemes
7/.	Large-scale schemes in Kenya relates to those managed by national Irrigation Board

Drainage plays an important part in reducing over irrigation and overcoming poor management within irrigated areas, as well as coping with excessive increased runoff deriving from catchment degradation. It is also important in controlling flooding and in reclaiming saline soils. Experience within all of the Nile Basin countries has shown that problems are resulting not only from inadequate drainage, but through insufficient maintenance whereby drains are blocked by reeds, weeds and sediment deposits. Reports undertaken for ENTRO confirm that salinity and drainage problems are on the increase within the basin and this is endorsed by the FAO database. Limited information is available on the drainage problems in Uganda, but drainage improvement is needed on most existing irrigated areas in Kenya and Sudan reports the deterioration in drainage systems in their large irrigation schemes like Gezira. Egypt has a large programme for overcoming salinity and waterlogging coupled with their programme for reuse of drainage water.

Traditional and permanent wetlands play an important part in the ecological environment as well as in the hydrology of the Nile Basin. They are being increasingly used for recession and seasonal irrigation in an uncoordinated manner, resulting from population pressures coupled with variable rainfall. Such developments must be carefully controlled and monitored, and recent programmes in Kenya, Rwanda and Sudan to reclaim wetlands must be undertaken with extreme caution.

2.3.4 Public Irrigation Schemes

Under a separate consultancy support[58] for Best Practices in Large Scale Irrigation systems of the Nile Basin, agricultural water use and water productivity will be examined using remote sensing techniques together with ground truthing. The work will focus on the identification and documentation of LSI schemes in the basin, and providing a detailed description and documentation of the "Best Practices" and "Best Practice Sites". The level of irrigation performance will be compared to other irrigation schemes in the world using a standard set of indicators. Appropriate guidelines for the implementation of some of the identified global/basin wide best practices will also be prepared and made available.

The performance and situation on these schemes is thus not dealt with in detail in this report. However, many of the problems experienced on these LSI schemes are mirrored in a smaller scale on the small scale irrigation schemes. It is therefore hoped that the techniques developed

[58] Dr. W.G.M. (Wim) Bastiaanssen, Water Resources Management and Remote Sensing Specialist, WaterWatch, Generaal Foulkesweg 28, 6703 BS Wageningen, The Netherlands.

for the LSI schemes could then be applied to the SSI using remote sensing, and this will provide a valuable tool for the Nile Basin governments when establishing priority lists for interventions and improvements.

Issue/Constraint: *Performance of large scale and public managed irrigation schemes has been low. These offer the greatest possibilities for improved productivity and for meeting the demands for food within the country. Expert technical advice on improvements and possibilities must be provided to the Federal/Regional Governments who generally lack sufficient experience in managing such systems.*

Although the definition of large scale irrigation scheme varies, it is generally accepted within the upper reaches of the Nile Basin that these comprise of those schemes of more than 1,000 ha[59]. Many of these schemes involve smallholder farmers, but are still regarded as medium to large scale, due to the management requirements and resources needed for the system. All have been developed by government or the private sector for crop production on a larger scale with cropping patterns and water delivery initially being determined by managing organisation. MOM has been provided by the same organisation, and in some cases the communities will have been required to contribute from the start of the project. In other cases, O & M charges will have been introduced at a later stage but may not represent the full costs involved in providing water delivery service to farmers.

The performance of these schemes in government hands has been poor in the past and many have been now transferred to private sector (either as managers or owner/operators. These schemes have been subjected to IMT in a number of countries, so that management at the appropriate level is handed over to the community with adequate training. In Egypt for example, with time, farmers have been able to take over O&M of the high-level systems once they have shown capacity at the farm and tertiary level. Some sources regard such cases as community managed irrigation, but they are better considered as public/private partnerships where the lower levels of the system have been handed over to the communities for operation and maintenance and maybe management as well. Public/Private schemes can comprise those where the privates sector has joined with Government to Manage, Operate and Maintain (MOM) the schemes but these can also include those schemes where some of the management is with government (and hence public) and some with the communities benefiting from them (such is the case in Egypt).

2.3.5 Private Irrigation Schemes

There is limited detailed information on the private irrigations schemes within the Nile Basin, particularly as government has limited direct dealings with them. Many comprise sugar estates that had formerly been in the hands of government and generally poorly managed with marginal profitability. For example in Tanzania, the now private sugar schemes are working very efficiently and have turned an annual US$ 7 million deficit into significant profits. In addition, there has been an increase in private out growers who also supply the factories. Other private sector crops include rice, vegetables, flowers and fruit at different scales. Most of the schemes are less than 3000 ha, except for the sugar estates. These will be covered in more detail under the separate LSI consultancy (together with the large scale irrigation schemes).

2.3.6 Development costs

Per hectare costs of small-scale irrigation schemes vary greatly across the Nile Basin. For schemes involving river diversion, capital costs range from US$ 1,500 to US$ 5,000 per

[59] The minutes of the Inception Phase Workshop on Large Scale Irrigation, March 2008, stated "Size accepted internationally is 10,000 ha but every country has its own definition".

hectare for new schemes, and from US$ 800 to US$ 3,000 per hectare for rehabilitated and improved systems. Where storage is involved (small dams) capital costs can increase considerably ranging from US$ 5,000 to US$ 20,000 per hectare. For rehabilitation and improvement of storage schemes, costs are in line with the non-storage schemes unless major defects in the dam or reservoir are identified. Annual operation and maintenance (O&M) costs per hectare have not been carefully analysed with many estimates based on theoretical percentages of capital investments rather than on needs and capacity for repayment in relation to net returns. Figures quoted range from US$ 40 to US$ 150 per hectare for non-storage schemes, and US$ 150 to US$ 250 per hectare for storage related schemes. Many governments have not paid attention to the opportunity cost of investments in irrigation facilities or the ability of users to pay for and maintain them. Although higher investments can result in a reduction in annual operation and maintenance costs, in most cases this approach has not been followed with schemes being unnecessarily complicated with large cost over runs during construction. An examination of costs across the basin has shown that development costs can reach above US$ 12,000 per hectare on a regular basis with many rising above US$ 20,00/ha once all investment costs have been taken into account. This high cost is often attributed to the construction of expensive headworks or wide spread canal lining. In most CMI and large scale irrigation schemes, surface irrigation is used. Few utilise sprinkler or drip irrigation and where these are involved, investment and O&M costs will be higher with well designed and appropriate systems costing around US$ 5,000/ha for complete installation.

2.4 Water Harvesting

Water harvesting is aimed at utilising rainfall and run off close to the point at which it falls. A wide range of techniques are involved (see Section for an assessment of the practices in use) and many examples of successful and good practices can be found in the Nile Basin countries. These techniques include improved forestation and reductions in the rate of run off from sub catchments, in-situ measures for retention of more moisture on the cultivated lands, structural storage of water for crop and human/livestock use, valley tanks and small dams, subsurface dams and spate irrigation[60]. In the short term, these types of interventions will have minimum implications and affect on the downstream Nile Basin countries as non-structural interventions take significant periods to realise their full benefits. However, within a 5-10 year time frame, if the approaches have been successful and planned in a systematic and holistic way, the measures can be expected to have downstream transboundary benefits, including a reduction in sediment transport and the rate of run-off following storms. It is anticipated that flood peaks for a given return period would the reduced and that base flows during dry periods would be increased. Such measures are essential considering the predictions for long-term flow in the Nile and the intensity and damage caused by flood flows in all Nile Basin countries as a result of climate change.

Recent decades have seen increased interest in lower cost alternatives to irrigation. Of these – although the boundaries between them may be blurred – a distinction may be drawn between two major types: *water harvesting*, which involves the collection and use of run-off, and *in situ* rainwater management, which involves reducing run-off by improving the infiltration of rainwater where it falls, storage in the soil profile and increased uptake by crops. Water

Examples of Water Harvesting Practices in the Nile Basin Countries

- Dam construction to reduce damage through rapid runoff and flash flooding (mainly in Egypt). The stored water can be directly used in irrigation, drinking or recharging the groundwater. (In south Sinai more than 25 dams were constructed where others are under construction and some are planned to be implemented);
- Catchment improvements to improve the vegetative cover, to reduce the rate of run-off and increase water available for rainfed crops (Mainly in the upper Nile basin countries);
- Improvements within the rainfed arable areas to reduce the speed of run-off and to increase the infiltration of the water into the soil (this has to be tempered with the need for adequate drainage within the arable area for certain crops and certain rainfall intensities. Safe disposal of excess water is an essential and often overlook component). This is very common in Ethiopia, Kenya, Uganda, Rwanda and Tanzania;
- Improvements to the watercourses and drainage lines within the catchment and also within the arable areas to reduce the speed of run-off, and hence erosion, and to permit a greater recharge of the groundwater;

[60] Details of best practices in water harvesting and technologies available are included in Part III (section).

harvesting can be considered as a form of irrigation, since it involves collecting water to augment that directly available to crops from rainfall; it should not necessarily be regarded as a 'new alternative' to irrigation.

Examples of Water Harvesting Practices in the Nile Basin Countries

- Diversion of surface run-off into small ponds for livestock drinking, recharge of wells for community drinking, or for small-scale agricultural production (horticulture and backyard crops). This is common in all Nile basin countries except Egypt, but the uses and technologies used vary).
- Spate irrigation - the diversion of significant peak run off directly onto rain fed agricultural land to supplement inadequate rainfall (either in amount or to compensate for long periods without rainfall). This is found mostly in Sudan, but also in the drier areas of Kenya, Tanzania and Ethiopia.
- Recession irrigation and wetlands irrigation/drainage (common in Uganda and around Lake Victoria);
- Collection of rainfall from roofs for drinking water (in all Nile Basin Countries).

Integrated watershed management approaches have been successful and need to be more widely adopted especially in catchments above irrigation schemes. The skill is in identifying the measures and approaches that assist those marginalised people living in these catchment areas, and who have over time been pushed into the areas where conservation is required, but who have little incentive to assist in this, as they are not the beneficiaries of the measures to be taken. In spite of the successes achieved, for example integrated watershed management programmes in Ethiopia and in Lare in Kenya, wide-scale adoption has not taken place. This is one of the major challenges facing water harvesting in the Nile Basin. Technologies are available, proven and manageable, but governments and donors have not mainstreamed the interventions. Implementation has been largely undertaken by NGOs and research organisations working with communities and local organisations with governments unwilling to invest time and effort into promoting the ideas and training and equipping field staff. Where governments do become involved, they often adopt wide-scale programs without first piloting possible approaches for subsequent upscaling[61].

Issue/Concern: *It is essential that the profile of water harvesting is raised in all Nile Basin Countries so that it is included in all national water legislation frameworks and through this process is put high on the agendas of all governments and donors.*

In situ rainwater management for upgrading rainfed cropping has yielded promising results. Reduced or zero tillage, for example, has been found feasible and widely adopted in various regions of the world. The rationale for investment in managing rainwater *in situ* is sound: improved rainfed cropping has much greater potential – in terms of cropped area and numbers of potential beneficiaries – than irrigation development. Yet adoption in sub-Saharan Africa has generally been poor.

Structural storage of water in small sub-surface structures, ponds, behind small earth dams and sand river dams have shown marked returns for those benefiting communities. Such interventions provide benefits not only in crop production, but also in meeting the water needs

[61] In 2004, the Ethiopian government embarked on large scale water harvesting using small scale storage ponds for agricultural production with successes at a lower level than would have been achieved if a more moderate approach had been followed.

of humans, livestock and for aquiculture. Although water needs may not be met under all conditions, the measures can provide sufficient water for much of the dry periods of the year and benefit the poorer and vulnerable members of the rural communities. However, there has been limited adoption of water harvesting techniques for improving and conserving water.

Issue/Constraint: *There is insufficient adoption of rainwater harvesting for domestic drinking water in rural areas and for backyard crop cultivation from storage. Most affected from the effects of scarce water are women and children who are primarily given the role of fetching water.*

There is considerable scope for improving adoption through the establishment of methodologies for identifying suitable locations for water harvesting in each Nile Basin country, for each type of water harvesting technology and building on the general very useful work of RELMA (CGIAR). The type of interventions that can be used will depend upon the location with respect to soils, slope, rainfall, etc. and attention has to be put on identifying the agro-ecological zones in which practices are carried out. This will enable the potential for up-scaling to be approached in a more systematic manner (see section).

Much work has been carried out on design methodology and manuals produced for different types of intervention[62]. These are not widely available in the Nile Basin countries and in spite of efforts of RELMA over the years; they are now in short supply or know to those who need them at community level. Many manuals reuse existing material with others providing improved and innovative approaches. What appears to be lacking is good simple technical implementation guidelines aimed at field staff assisting communities to equip them with full information on technologies types and the conditions under which they will operate effectively. Under the second phase of this EWUAP consultancy, efforts will be made to bring all the existing manuals and design notes together for use and upscaling through out the Nile Basin. The skill in achieving success in water harvesting structures is in the correct choice of technology and the adaptation to site, an issue that is not sufficiently emphasized in the multitude of manuals available.

2.4.1 Cost of RWH Interventions

Even though the costs of implementing RWH vary with countries and regions, availability of local materials and local operating conditions, basic costs per cubic metre of water are generally comparable for specified RWH technologies. Typical costs for RWH storage tanks are given below (Table 3.5). Cost estimates must be determined for each specific site and include separately those activities that can be undertaken by communities as part of their contribution.

[62] During Phase 2 of this Consultancy, these will be sued to produce a water harvesting manual that provides cross references as to where more information can be obtained.

Table 3.5 Indicative Costs for RWH Storage Tanks

Technology	Typical example	Cost	Unit
Under ground tanks	Concrete dome shaped tank	7	US $/m³
	Brick dome shaped tank	9 to 14	US $/m³
	Bottle shaped tank	4	US $/m³
	Ferrocement tank	12 to 15	US $/m³
	Ball shaped plastic tank	160	US $/m³
Above ground tanks	Brick tank	93	US $/m³
	Ferrocement tank	30 to 70	US $/m³
	Plastic tank	130	US $/m³
Runoff open reservoirs	Plastic lined	3	US $/m³
	Cement lined	5	US $/m³
	Unlined	100	d/ha
	Lined oval tank	8	US $/m³
Runoff closed reservoirs	Concrete dome shaped underground tank	7	US $/m³
	Brick dome shaped underground tank	9 to 14	US $/m³
	Bottle shaped underground tank	4.0	US $/m³
	Ferrocement underground tank	13	US $/m³
	Hemi spherical underground tank	23	US $/m³
	Sausage shaped tank with cement lining	16	US $/m³
In situ	Human land preparation	113	h/ha
	Draught Animal Power land preparation	53	h/ha
Sand or sub-surface dams	Sand dam	0.8	US $/m³
	Sub surface dam	0.7	US $/m³
Rock catchments	Open rock dam with stone gutters	71	US $/m³
	Closed rock dam with stone gutters	89	US $/m³
	Open rock dam with tank	110	US $/m³
	Rock catchment tank with stone gutters	46	US $/m³
	Stone gutters	2	US $/m

NB: Local material and labour can be provided by the community

(Source: Desta et al, 2005; Nissen-Petersen, 2000)

2.5 Current Water Use and Practices

Throughout the upper Nile Basin, studies have shown that irrigators and farmers have insufficient experience of irrigation water control, water harvesting and conservation techniques. Surface irrigation is used almost exclusively by smallholder/community irrigators for water application. On commercial and private farms other more efficient water application measures are used, as farmers are fully aware of the need to relate water use to productivity. Significant areas of sprinkler and drip irrigation are adopted for crops such as flowers, sugarcane and vegetables). Poor water management techniques are used by many farmers at the moment, and there is a need for farmers and water utilization agencies to be advised on best practices and to become familiar with the optimum quantities of water to be used for their needs. Irrigation efficiency is a term used to describe this situation, but has tended to approach the issue from an engineering viewpoint rather than from the crop moisture needs[63]. Low irrigation (conveyance & application) efficiency is not necessarily bad as long as water is recaptured and recycled and does not inhibit crop growth. The provision of irrigation water relates to the *service* of providing the correct amount (volume) of water at the right place and time. *On-farm water management* relates to ability of the irrigation systems in place to get the water to the crop, the crop selection, sowing dates, fertilizers applied, all of which culminate in a certain water use for biomass production. Any assistance and support provided to farmers

[63] See glossary of terms and definitions at the beginning of this report for more explanation of these terms

must therefore aim at making irrigation successful, which is measured in terms of land productivity (kg/ha) and water productivity (kg/m^3).

Issue/Constraint: *There is a significant gap between the recommended and currently applied agronomic and water management practices. Higher levels of advice are needed by all irrigation schemes and a better system of providing suitable extension services for irrigated areas is required. To include this with rainfed extension services has not been successful in all Riparian countries.*

2.5.1 Water Allocation and Management

Throughout the riparian countries, different approaches are adopted for allocating and managing water. In the Middle and Lower Nile, good levels of measurement and management enable water to be provided according to pre-determined needs and to take some account of changing weather patterns. In the Upper Nile Basin countries, less control is exercised with users being able to abstract water where and when they deem fit rather than in an organised and equitable manner. Licensing and registration of users existed in the past, but this has not been enforced resulting in conflicts and inequitable use of resources[64]. With water shortages being felt throughout the Nile Basin, measures are being put in place to alter this. Recent developments in a number of countries have shown that by addressing water resources management and irrigation simultaneously, water abstractions can be rationalised with other upstream and downstream users. This has been facilitated by the registration of water rights by all schemes in one main catchment and the preparation of annual allocations based on agreed cropping patterns. As farmers pay for their water and need to plan its use in advance, there has already been a trend in some areas towards high value horticulture during the dry season, where returns to labour are higher and water requirements are less and where market linkages have been established. Beneficiary driven Irrigation Organisations have been established to manage water use and distribution within the schemes and for the operation and maintenance of the systems. They are capable and willing to collect water charges from the members and have shown that they can be made responsible for paying not only the annual water right charges but for also meeting the costs of non-labour O & M.

Issue/Constraint: *Lessons learnt from RBMSIIP in Tanzania need wider application to improve overall water management. Riparian states need to be aware/benefit from experiences in other Nile basin countries.*

Few traditional (smallholder) schemes have adequate intake water control and a means of flow measurement. Abstraction and distribution systems are built with limited water control structures and those that are in place do not necessarily meet the water control needs of the communities. Such schemes also often lack a drainage system to cope with management deficiencies and natural excesses. For the newer and rehabilitated/improved CMI schemes, a better situation is found although in many cases structures have been rebuilt to the original situation, often repeating the earlier mistakes. Insufficient attention is given to water measurement and how management of the diverted water will actually be carried out. Poor intakes mean that a significant fluctuation in delivery of irrigation water occurs, flood flows can enter the systems and in parts of the schemes, irrigation water is unpredictable thereby diminishing crop yields. Access to water is thus uneven and there are major water management problems.

[64] Most traditional irrigation schemes in Tanzania have poor irrigation efficiencies (<15%) and conflicts between upstream and downstream users are increasing as the variability of rainfall amounts and timing increases.

Issue/Constraint: *Conflicts between upstream and downstream water users are increasing in many parts of the Nile Basin. New diversions or pumps are installed upstream of existing diversion weirs resulting in shortage of water for existing schemes. Such cases are taken to court and other authorities, but as there are no legal rights to water in many Riparian states, no immediate solution is often available.*

2.5.2 Water storage

A large number of small storage dams, valley tanks, pans, Haffir and other structures are used throughout the Nile Basin for both livestock watering, domestic water supply and agriculture. Many of these have existed since much earlier times. Improvements have been made to these structures and additional sites have been developed. However, as a result of catchment degradation the rate of runoff has increased and many of such dams and structures have failed due to overtopping of the dam resulting from insufficient spillway capacities. Recent experience with small dam construction in the basin has shown that many of the works undertaken lacked sufficient engineering knowledge and an understanding of local hydrology. Suitable manuals are available, but some are simplistic or too complicated for use by the less experienced staff charged with the implementation works. Small storage structures have been shown to not only provide direct benefits to the communities, but also have a very important secondary benefit of groundwater recharge.

Concern: *There is a need to approach small dam construction in a more scientific way to ensure that the construction is sustainable and that where possible structures are located off- channel if limited hydrological information are available.*

With increasing catchment degradation, sedimentation of dams is now of major concern, irrespective of dam size. All storage dams suffer a reduction in capacity as a result of sedimentation and in Sudan; Roseires, Sennar and Khasm El Girba reservoirs are reported to have lost 30%, 40%, and 60% respectively of their original capacities. Special procedures are required at Roseires to suspend energy production while flushing the bulk of the sediment that arrives at the beginning of the flood season through the reservoir and dam. Results from Tigray in Ethiopia have shown that sedimentation rates for small dams planned for irrigation were actually 3-4 times more than allowed for in the original designs. The same is true with valley dams and ponds/pans unless measures are taken to reduce the sediment flow at the inlet to the reservoir. In many cases, dam construction has taken place without any treatment to the catchments or exclusion measures partly due to the lack of experience of the designers and partly due to cost reasons.

Issue/Concern: *Construction of small dams and ponds need to be accompanied by sediment exclusion measures and catchment treatments to reduce erosion.*

Inlet channels also experience significant problems from sediment deposits due both to blocking of intakes on rivers, as well as causing changes in river direction and local elevations. In some countries such as Sudan, river training and bank protection become major areas for investment for irrigation systems. The situation is often more severe during good rainy seasons as water needs become less and sediment transport capacities become much higher. To overcome many of the problems, high recurrent expenditures are needed to dredge rivers annually and to provide river training works. Attempts have been made to remove silt from small dams, but this has not been successful or economic. Longer term action is needed in the catchment areas and this is true throughout the Nile Basin. Reports of excessive locations of erosion, such as Rwanda, are often not corroborated by research data. Significant problems occur through stream bank erosion and cultivation close to the edge of water courses rather than to poor practices in the upper catchments. However, measures are needed which should be related to the clearly identified cause and not the effect. .

Issue/Constraint: *Sedimentation is a major problem for many dams as estimates of possible accumulation rates design are based on old field information and generalised formula that underestimate actual sedimentation rates. More conservative values are needed together with catchment conservation works implemented at the same time as storage and irrigation works.*

2.5.3 Irrigation efficiencies

Data on conveyance and application efficiencies for irrigation systems within the Nile Basin are limited, with no data available for private growers. Measurements of irrigation efficiency are made in a few countries but it is not clear whether actual flow is measured to compute conveyance and application efficiencies. When water delivered is compared with water used, low overall productivity is achieved. Data available from adjacent basins give a good indication of the level of efficiency and related management practices that occur in the countries are obtained. Estimates for major farms in the Awash Basin of Ethiopia (Table 3.6) illustrate the overall low efficiencies that are achieved on many state controlled large scale schemes. Data for northern Ethiopia (Table 3.7) show that considerable scope exists for the improvement of conveyance efficiencies and water productivity.

Table 3.6 **Estimates of Irrigation Efficiencies for Major Farms in the Awash River Basin**

Farm Name	Major Crop Grown	Overall Irrigation Efficiency (%)
Wonji – Shewa	Sugar cane	50
Nura Era Complex	Horticulture	30
Metahara and Abadir	Sugar cane	50 – 55
Amibara	Cotton	50
Angelele Pump Scheme	Cotton	35 – 40
Gewane	Cotton	35
Dubti, Dit Bahri	Cotton	35 – 40
Assaita	Cotton	30
Small Settlement Farms		30 - 35

Source: Rapid baseline Assessment, Ethiopia. 2007.

Table 3.7 **Conveyance and Application Efficiencies in Three CMI Schemes in Tekeze basin**

Parameter	Community Managed Irrigation Scheme (%)		
	Meila	Haiba	Mai Negus
Conveyance Efficiency	74.8	53.2	58.26
Application Efficiency (when rooting depth was at about 20 cm)	72.84	64.7	85.4
Irrigation Efficiency	54.48	34.42	49.75

Source: Rapid baseline Assessment, Ethiopia. 2007.

Specific measurements of scheme efficiency were made in Tanzania for the River Basin Management and Small-Scale Irrigation Improvement project (Table 3.8)[65]. Although the results showed an improvement in overall efficiency in the dry season, during the wet season, farmers were involved in other rainfed land away from the scheme and were thus not able to dedicate the time needed on the irrigated plots. This illustrated the need to fully understand the farming systems of the participating farmers as well as their sources of income before investing heavily in scheme improvements.

[65] World Bank 2004b

Table 3.8 **Comparative Water Use Efficiency Before and After Scheme Improvement**

Scheme	Wet Season				Dry Season			
	Ec	Eb	Ea	E	Ec	Eb	Ea	E
Base Line data	40%	55%	34%	7%	60%	60%	38%	14%
After Scheme Improvement	83%	60%	36%	18%	86%	76%	47%	30%
Percentage Change	**108%**	**9%**	**6%**	**157%**	**43%**	**27%**	**24%**	**114%**

Notes
E = Overall Efficiency
Ec = Conveyance Efficiency
Eb =Field Canal Efficiency
Ea = Application Efficiency

Issue/Constraint: *Water distribution methods should be determined, based on local conditions as well as social, technical and economic considerations and within the capacity and resources of the community to manage and maintain them. Attention needs to be given more to productivity and efficiency of water use.*

2.5.4 Water Constraints

Water is an annual constraint in most riparian countries (see issues/constraints raised in each Rapid Baseline Assessment report – Annexes A-I). Improved water efficiency and water management practices will be the driving force behind future irrigation support and developments, leading to greater agricultural productivity and increases in sustainability in the sector. Not only will this cover traditional irrigation, but all scales of irrigation schemes including former Parastatals and water harvesting in the complete sense including soil and water conservation, rainwater harvesting and storage. Appropriate policies and strategies are not yet in place in many of the Nile Basin countries and need to be developed and implemented by the relevant government organisation. Particular attention needs to be paid to ensuring long-term sustainability of water resources and making agriculture a competitive user of water in comparison with other sectors. Efforts have been made to achieve this in the past, but have been thwarted by local politics and lack of adequate support. Full understanding and support of NILE-COM is needed to achieve these objectives.

2.6 Other Constraints to Irrigation and Water Harvesting Development

2.6.1 Physical Constraints

Soil Fertility: Fertiliser use in the upper parts of the Nile Basin particularly in smallholder agriculture is among the lowest in the world. Current level of application in Uganda is estimated at less than 1 kg of plant nutrient per ha compared to the average for Sub-Saharan Africa of 9 kg/ha[66]. In addition, while the developing world and virtually every African country taken individually have increased fertiliser use by 2-3 times or more in some cases, some states (Rwanda; Burundi; Uganda) have fallen behind by a factor of about four over the same period. Reasons for this have been partly due to the assumed belief that soils are traditionally fertile, but most importantly due to financial and availability constraints (cost; access to fertilizer; availability of credit).

Concern: *Any promotion for improved fertilizer use must be based on the farmer's needs, resource availability, use of organic fertilizers and affordability.*

[66] This represents only 20% of that used in Latin America and 5% of that used in East Asia.

Land degradation: Rainfed agriculture and livestock grazing are the most widespread land uses in the Nile Basin and these activities are associated with serious and accelerating environmental degradation. Degradation in this sense means a diminution of the biological productivity expected of a given tract of land being used in a particular way. On a farm, it may be reflected in lower crop yields, on a savannah in fewer livestock units and in a nature reserve in fewer plant and animal species. The soil on degraded lands is typically impoverished or eroded, there is less water available due to increased surface runoff or contamination, plant and animal productivity is lower, and wildlife less diverse. Soil erosion impacts include dramatic increases in the frequency and intensity of floods and droughts, habitat damage related to sedimentation impacts downstream and disruption of natural ground water recharging. Soil erosion harms productivity by depositing silt in reservoirs reducing the storage capacity of dams, irrigation systems, river transport channels, and by damaging fisheries.

Data on the measured extent of degraded land in the Nile Basin or elsewhere[67] is limited, but the anecdotal evidence supporting accelerated deterioration in land productivity is compelling. The most important causes are deforestation, cultivation of unsuitable marginal lands, inappropriate or excessive use of agricultural technologies and chemicals, over grazing - particularly in arid and semi-arid lands - and poor management of cultivated land, often exacerbated by drought. All lead to depletion of soil fertility and water and wind erosion. Degradation on arid, semi-arid and sub humid lands leads to desertification with desert-like conditions appearing where none existed before. Vast areas of thin, sandy topsoil on desert fringes are affected by wind erosion in flatter areas of the basin. The results include increasing deficits in food production, declining food security and greater human poverty. This is well evidenced in arid and semi-arid regions of Sudan with sand encroachment into agricultural land and settlements, removal of top soil by wind and water agents, loss of soil fertility, invasive species, riverbank erosion and salinization (64 million feddans of land deteriorated - 81% in arid/semi-arid regions). The clearing of trees has accelerated the problem with traditional rainfed agriculture around Atbara River having increasing gully erosion resulting in the loss of arable land at about 13.4 km^2 yr^{-1} and 9.8 km^2 yr^{-1} in the periods 1985-1987 and 1987-1990, respectively[68].

Issue/Constraint: *Growing population pressure in highland areas where rainfed agriculture predominates as resulted in a rapidly declining natural resource base that has secured irrigated agriculture a prominent position on all Nile basin countries development agendas.*

Water Quality[69]: The main threats to basin-wide water quality are insufficiently treated domestic, urban and industrial wastes, pollution from pesticide/fertilizer residues, siltation and sedimentation, increased salinity and wetlands loss. Increasingly, serious waterborne diseases are prevalent throughout the basin. Toxic and hazardous mining wastes represent dangers in some local areas. The costs of these threats are invariably borne by downstream users. Inferior water quality has a disproportionately large impact on poor households in rural areas and urban slums where access to uncontaminated water supplies is often limited. Women and girls in rural areas spend two or more hours per day fetching water due to scarce sources and limited access. The poor are more likely to live in marginal or less desirable areas, such as along polluted waterways and heavily polluted agricultural drains in irrigated areas, in degraded watersheds and in the vicinity of sewage treatment facilities and wastewater disposal sites. Their propensity to become sick is correspondingly greater, with negative impacts on their work and educational opportunities.

[67] Nile Basin Initiative, May 2001. Transboundary Environmental Analysis. Nile Basin Initiative, Shared Vision Program.
[68] Fadul et al (1999); Hussain et al (2006)
[69] See also section **.**

Sedimentation problems are necessarily closely related to soil erosion problems. High sediment loads are found in many rivers, especially those draining the mountainous areas that are severely affected by soil erosion. Sediment loads are very high in the Blue Nile, the Atbara and the rivers of the Kagera basin, as well as many of the other rivers flowing into Lake Victoria. These sediment loads from the upper catchment can increase by up to 30% during droughts[70]. Sedimentation in the White Nile catchment is also serious although the many lakes and wetlands in the basin trap much of the sediment and the flatter terrain is somewhat less susceptible to soil erosion. High sediment loads have adverse effects on canals in the major irrigation schemes and can degrade small wetlands and reduce the capacity of shallow lakes. Siltation of major reservoirs imposes direct economic costs by reducing the efficiency of irrigation and power production, sometimes necessitating expensive desilting operations. Sediment and debris carried by the Blue Nile, the Atbara and their tributaries affect available storage in Sudan's reservoirs and water quality in the canals in the Gezira, Rahad and Halfa irrigation schemes. Sediment deposition in some parts of the Nile between Atbara and Lake Nasser (Lake Nubia) has formed islands and sediment bars, leading to cross currents that have caused bank erosion and the loss of fertile soil and mature trees. Almost all of the sediment carried to the Nile's lower reaches becomes trapped in the Aswan High Dam, a reservoir which is estimated to have a large enough capacity to store sediment inputs for hundreds of years without impairing hydroelectric power generation.

2.6.2 Support services

Extension Services

In every Nile Basin country, the issue of inadequate extension services has been raised[71]. In many cases, it has been assumed that staff dealing with rainfed agriculture can also manage extension services for irrigated agriculture. This is rarely the case and requires different skills and experience. Yields within are generally poor, with low productivity and low water use efficiency. Extension support needs to be improved in order to realize the full potential. The success of irrigation productivity improvements will rest on the ability to provide the lacking extension support. Many efforts to improve upon the quality and service provided by government extension services in Africa have failed to produce results, and have also increased the financial burden on government. Many vehicles have been procured, staff trained and manuals produced, but widespread impacts have yet to be felt. The Farmers Field School (FFS) approach introduced by FAO has been introduced into most Nile Basin countries[72] and continues to be used in many areas. It appears to be successful considering the limited number of extension workers and resources available. However, considerable financial support is needed to train extension staff and farmers who need additional advice in areas of financial management, water management, improvement of agricultural practices and technology, accessibility to inputs and appropriate market outlets.

Farmers face many problems relating to adaptability of crops to their local conditions. In many cases they are unable to access new varieties or those trialled successfully on research stations. Throughout the Nile Basin it has been found that the research system is not closely linked to the farmer with many researchers working in isolation and not working towards applied research for the benefit of the farming communities.

[70] See also section **.**

[71] For example, national statistics in Uganda (National Household Survey, 1995-6) indicate that extension officers only visited 16%, 33%, 9% of areas in Central, Eastern and Western regions. In Ethiopia, IFAD (2005) found that “The poor extension support to irrigated agriculture including the establishment or strengthening of WUAs and SWC works in catchments is a threat to the sustainability of interventions in irrigation”.

[72] E.g. In Western Kenya (Kakamega, Bungoma and Busia).

Issue/Constraint: *Extension/support Services to irrigated and rainfed areas needs to be significantly improved to ensure that appropriate advice is provided and that poorer/ resource poor farmers are not marginalised.*

2.6.2.1 Marketing

Marketing throughout the Nile Basin is constrained by long distances to produce markets[73], impassable roads and lack of affordable transport. Much of the transport infrastructure is impassable in the rainy seasons and causes damage to the transported produce at other times. The issues related to marketing are complex and vary through the Basin, but there are many commonalities (see box below).

Market Constraints in the Nile basin Countries

- The restricted access to markets and market dues constrains the produce that farmers can grow;
- Access is difficult with ready markets not available for sale of produce and purchase of inputs;
- Poor prices received by farmers due to poor market linkages and domination of the market by traders who dictate prices to farmers;
- Oversupply at harvest time & depression of prices;
- Insufficient advice on planning of crops and staggering of crop planting dates has been available to farmers;
- High market dues for produce sales;
- Poor market facilities - women appear to be most affected by inadequate market facilities, such as sanitation or shelter. Although both men and women are involved in marketing, women may have limited access to the profit;
- The availability of statistics regarding food crops and export crops is unsatisfactory with many agencies involved in the collection and dissemination of agricultural data;
- Relatively low incomes that eat into market profits and limit the amount that can be spent on looking for suitable outlet;
- Little to no access to credit for many disadvantaged traditional farmers due to their inability to provide co-operative guarantees or personal guarantees acceptable to banks;
- Banks are unaccustomed to working with the poor and see it as inherently risky.
- Group collateral as a substitute for personal guarantees has not been well tried and is thus not well recognised;
- Informal sources currently provide most of the financial needs of the poor, but at a relatively high cost;
- Rich farmers usually extend loans to poorer landowners and tenants in exchange for part of their yields.
- At times, money lenders, shopkeepers, middlemen also provide credit but the effective annual rates of interest are often much higher than the formal sources of finances;

Attempts to improve marketing have met with mixed results and have been successful when outlets and linkages have been established prior to crop production. Quality of produce and continuity of supply remain overriding aspects of successful marketing. Conditions that are often difficult to achieve in smallholder schemes where farmers are often not well organised and individual approaches are often preferred.

[73] Statistics from Uganda show that the average distance to a periodic consumer market for sale of produce is 5 km (25% of the population living within 1 km) and that it is an average of 11 km to a major market.

2.6.3 Institutional Constraints[74]

Management, operation and maintenance (MOM) of irrigation schemes has been inadequate in many countries, and is one of the primary causes of poor water use and low productivities. A lack of guidance in irrigation O&M at local level, either sub district or district level, has meant that farmers have relied too much on government support for maintenance tasks, many of which could have been handled by participating with the community at the early stage of the project cycle. All governments have identified the need to involve users more in all aspects of scheme management/development and thereby be more prepared to contribute and be involved in improvements that will benefit them directly. As many schemes have a backlog of deferred maintenance, it is unreasonable to expect them to pay 100% for repairing and upgrading of systems that have deteriorated due to insufficient investments when under government control[75], but some contribution is important to ensure their commitment. The variable condition of the systems results in insufficient funding of O&M due to the lack of investments to overcome the deferred maintenance. When WUAs take over, they must be required to deal with only routine O & M, and not capital expenditure to restore it to the condition in which it should have been at handover.

Issue/Concern: *The accumulation of deferred works on many unassisted schemes means that expenditure can only be planned on an annual basis without attempting to assess future O&M needs and contributions to achieve them. No provisions can thus be made for replacement of key structures and facilities such as gates should they fail or suffer severe damage.*

There are many useful experiences that can be gained from examining experiences and traditional means for overcoming annual problems of operation and maintenance. For example in Eastern Sudan, the successful experiences obtained over the years in Kassala to reduce O&M budgets related to canal cleaning and silt exclusion can be applied to other parts of the country. Annual accumulation of silt in channels results in very high costs in O&M budget, and thus designs must accommodate measures that permit a reduction in the amounts of sediment entering headworks and main canals.

Issue/Constraint: *The organizational structure of indigenous irrigation schemes has a vital role in the sustainability of small scale irrigation schemes with members fully participating in maintenance activities and having a firm stand against water theft and observance of unwritten byelaws and elected leaders. These attitudes are contrary to those in many Government/NGO initiated schemes.*

Insufficient attention has been paid to proper establishment and empowerment of WUAs who were insufficiently trained to manage schemes in a technically, economically and socially sustainable way. Enabling legislation essential to their effective operation has not been facilitated, and modules for training prepared in other countries have not been made available or utilised for similar exercises in neighbouring countries. In many cases, farmer involvement has not been sufficiently participatory although it has been stated as such, with the true understanding of the farmers not being achieved and resulting in the collapse of the WUA once project support has been removed.

[74] (See also section **6**).
[75] Many of the irrigation and drainage schemes in operation were built some time ago and a large number have been in service for more than 25 years.

Issue/Concern: *Users have limited past involvement in the irrigation and drainage systems and how they were designed and built. Before handover is carried out, the beneficiaries through the WUAs need to be fully involved in the planning and implementation of the rehabilitation and upgrading works so that they understand the full implications of receiving the 'completed' works that they are required to maintain.*

In the past, WUA members have been producing profitable crops and could afford to pay for the services provided. However, with increasing input costs and greater market competition, incomes have declining and service charges have been making up a higher proportion of the crop budgets.

Issue/Concern: *To avoid WUAs spending too much on staff and other costs in relation to the amounts allocated to maintenance and keeping the systems in good repair. The key aspect is to determine the desired level of expenditure in maintenance to initially overcome past under investments and then to maintain the systems adequately. See section on Asset Management.*

.3 EFFICIENT WATER USE FOR AGRICULTURAL PRODUCTION

Improved water efficiency and water management practices will be the driving force behind the future plans for improvement of existing irrigation development in the Nile Basin countries. It will lead to greater productivity and increase the sustainability of interventions in the sector. Not only will this cover traditional irrigation, but all schemes including small scale/community managed schemes, former state farms, large scale schemes, parastatals and water harvesting in the complete sense including soil and water conservation, rainwater harvesting and storage. Appropriate policies and strategies will need to be developed paying particular attention to ensuring long-term sustainability of water resources and making agriculture a competitive user of water in comparison with other sectors.

Issue/Constraint: *If Nile Basin Countries are to seriously address problems of poverty and food deficits, they must increase the support to irrigation development and most importantly the productivity of existing irrigation systems. Improvements in rainfed agriculture will be slow to materialise and will fail to make up the deficits and keep pace with the increasing demands resulting from population growth.*

Improving the efficiency of agricultural water use is a long-term process. Where water is becoming scarce, overt competition and conflicts over water among users will provide an incentive for adoption of legislation and technologies that save water. The efficient water use for agricultural production[76] (EWUAP) project is expected to contribute to awareness raising and understanding of such measures, which will assist riparian countries in the preparation and implementation of policies and strategies. Much of the success and sustainability will depend on whether the project outcomes will result in tangible benefits for stakeholders. As long-term benefits are likely to be less visible than the outcomes of, for example, direct infrastructure delivery, the project will need to remain alert to demonstrate tangible change for stakeholders. Incorporating regional experiences at the national level will need to form an important element of this strategy.

The concept of efficient water use for agricultural production (EWUAP) is aimed at ensuring greater production of crops per unit of water falling within a catchment (water harvesting), or diverted from a water source to an irrigated area (community or public-private irrigation). Although a number of factors are discussed in relation to poor water use, none of the documents clearly defines the factors involved in improving water use for agricultural production. It is sometimes loosely referred to as poor water management, but this rather oversimplifies the problems involved. These include social, institutional, economic, technical, environmental, and investment issues.

3.1 Factors Involved

Factors involved in efficient water use for agricultural production include (i) Management and related roles and responsibilities (WUAs and local Gov.); (ii) Irrigation management transfer (IMT); (iii) Markets (access; linkages; export; market driven); (iv) Irrigation system and distribution efficiency; (v) Irrigation method (surface flooding/improved, modern); (vi) Technologies available to farmer for irrigation/land preparation; and (vii) Water pricing, cost recovery and ability of farmer to pay. The related issues are presented in Table 4.1. The major challenge is to increase water use efficiencies. Worldwide examples of scheme efficiencies

[76] Defined here as "The optimisation of water used in agriculture for acquiring the maximum crop production per unit of consumptive use and to minimise the amount of water diverted to the agricultural land to meet this consumptive use." – see **Glossary of Terminology.**

prepared by FAO (2003) show that with an average scheme efficiency of about 40%, there is considerable scope for improvement. Current inefficient use of water calls out for adoption of modern irrigation systems (sprinklers and drip), which is a vital option to conserve water and raise value-added outputs in the sector. Modern systems can raise efficiency from 45% for traditional conveyance/application methods to 70 to 80% in modern systems. Adoption rates are slow due to the higher investments and greater technological understanding needed and is greater in vegetable or flower production where returns justify the extra costs.

When examining efficiency, it is important to recognize where the greatest losses take place. Although smallholder/small-scale irrigation schemes can often be very inefficient, benefits gained on these sites from improvements in efficiency will only be experienced locally where the freed up water will be used to cultivate larger areas at the periphery of existing command areas to accommodate population growth. The concentration on these schemes relating to freeing up water for transboundary use will detract from the places where significant improvements for the Basin can be achieved namely in large-scale irrigation (LSI)[77]. There is a tendency to think that significant institutional issues and constraints only exist on large-scale irrigation schemes. Experience within the Nile Basin has shown that the poor performance from small-scale/community managed irrigation and the failure to uptake the water harvesting technologies available by the communities, is as a direct result of institutional issues such as insufficient community involvement and identification with the proposals presented, and the role of farmers in scheme management. In many cases, only lip service has been paid to the discussions with the benefiting communities/water users associations and that once they have been initially discussed, that is all that is needed and they will understand and cooperate. Community commitment must be regarded, as a *process* that once initiated must be followed up with regular and targeted support.

3.1.1 Improved Agricultural Production

Irrigation and water harvesting have an extremely important role to play in both crop production and poverty alleviation. Yield levels are well below potential and in almost all Nile Basin countries are unable to produce sufficient grain and food crops to meet market demands and to keep pace with the increases resulting from the rising population. Rapid increases in crop yields and amounts produced are needed over the next 5-10 years and this cannot be achieved through area expansion of rainfed crops. Increases will only be achieved through intensification and improvements in production from the existing cultivated lands, both irrigated and rainfed. Irrigated and rainfed crop production must therefore go hand in hand, but where the irrigation potential exists, it should be developed. Future development will need to concentrate both on improved productivity per unit of land and water. Improvements in conveyance and application efficiency on existing irrigated land will result in the freeing of water for other areas and a scope for expansion of existing developments. However, this is not the only factor, with much more attention being paid to operation and management, and water being applied to plants at useful times and in quantities that they can readily use. Such methodologies can only be sustainably accommodated using a catchment approach to the integrated management of natural resources (including water), recognizing that river basin organizations provide a feasible mechanism for ensuring equality of water resource utilisation[78].

In general, water harvesting tends to take place at the individual level for the benefit of the household (such as back yard crop production, drinking water or livestock ponds). It will impact directly on household poverty reduction and livelihoods. By contrast, irrigation takes place at community level and benefits in improved crop production and yields are measured

[77] See section 2.3.4 above.
[78] This was successfully illustrated in Tanzania with the World Bank supported RBMSIIP.

at village, district, regional or national level, depending on the size of the irrigation scheme and the crops grown.

Issue/Constraint: *Declining landholding sizes due to population growth and deteriorating soil fertility are among the biggest challenges facing agricultural production systems in the Ethiopian highlands (FAO, 2005).*

Issue/Constraint: *Kenya's medium to high potential areas constitutes only 17 % of the total area, with rainfall of 700 mm/an. The remaining land mass, classified as arid or semi arid, requires irrigation for economical farming to be realized.*

Table 4.1 **Main Issues Involved in Efficient Water Use for Agriculture Production**

System Management and Related Roles and Responsibilities (WUAs and local Gov.)		
Water Users Associations.	(a) Good and well-trained water users associations are needed that feel empowered. This takes time [2]. A number of different parts of the programmes need to run in parallel, so that when the system has been rehabilitated and upgraded the WUAs are equipped to undertake the role is required of them. Preparation for rehabilitation and upgrading will take one to two years depending on the level of investments. (b) Community managed irrigation schemes will comprise a significant number of small farms that are individually owned by many farmer families. When resources are limited, designs may not be adequate, but farmers will muddle along with what they have got. Experience has shown that in the past governments have looked to improve the systems by investing in the infrastructure rather than first establishing cohesive groups to agree upon the improvements could be achieved.	
Irrigation Management Transfer (IMT).	<u>Management at the appropriate level</u>. For the community managed schemes and for the public irrigation schemes, this is an important factor since when farmers do not pay for the costs of managing operating and maintaining the systems (MOM), they do not appreciate firstly the full costs involved and secondly have no incentive for reducing the water applications. Where a fixed cost is imposed by a management authority on the communities for providing MOM without adequate consultation with the community or without considering the variations in benefits received, this can and will lead to complete failure of the scheme [1].	
Current water use and practices/ Irrigation method (surface flooding; improved surface; modern;)		
Water use efficiency	Improvement of existing irrigation development in the Nile Basin Countries; contribute to awareness raising and understanding of such measures; aimed at ensuring greater production of crops per unit of water.	
Returns to water/ productivity	Awareness raising and training; Establish procedures for introducing the concept of productivity and put in place measures for quantifying the results.	
Water Management:	**Main water distribution methods:**	**Description**
	On-demand:	Water is available to the farmer any time that the intake or hydrant is opened. Therefore the amounts to be used are not limited but water consumption is usually metered and paid for by cubic metre. These are high cost systems, which need a high level technology in the construction and maintenance.
	Semi-demand	Water is made available to the farmer within a few days (generally 2-7 days) of his request. The amount is often limited to a certain volume per hectare.
	Canal rotation and free demand	Secondary canals receive water by turns, for example every 7 days, and once the canal has water farmers can take the amount they need at the time they wish.
	Rotational system	Secondary canals receive water by turns and the individual farmers within a given canal area receives the water at a pre-set time and generally in a limited quantity.
	Continuous flow	Throughout the irrigation season, the farmer receives a small but continuous flow that compensates the daily crop evapotranspiration.
Irrigation System and Distribution efficiency;		
System Improvements.	Rehabilitation and upgrading of the system. It is often easy to identify the requirements for the main and secondary systems as the actions in the systems will be easier to implement - they are normally within the mandate of government or the public sector supplier. As such individual farmers will generally have little complaint to changes at that level. Improvements further down the systems will require more thought and planning as in many cases farmers and water users will have adapted the original systems in their own ways to meet their water demands. Deficiencies in topography, delivery capacity of the canals, and timing of water deliveries will have influenced the decisions made by the water users. Depending on the size of the system, and in general below secondary level, the	

	proposals will need to be carefully thought out as there are many players and incentives need to be clearly defined.
Operation and Maintenance	Development of annual O&M costs based on system requirements and farmers ability to pay. Establishment of regular procedures for assessing and implementing annual O&M plans.
Water measurement	Provision of system for measurement of water diverted especially into the system as well as to the point at which the Water Users Association will take over management (we need to know also whether there is a system in place for measuring water diverted and water utilised by the different users in the catchment and also for assessing how much is used at the end point and therefore arriving efficiency of application).
Asset management	Introduce approach to planners and managers at national level to ensure adequate funding of infrastructure.
Water pricing, cost recovery and the ability of the farmer to pay	
Water pricing	Experience has shown that an opportunity approach to pricing of water for agricultural use is counterproductive.
Markets (access; linkages; export; market driven)	Interventions to overcome the identified constraints (see section 2.6.2.1).
Technologies available to farmer for both for irrigation and land preparation;	
Technologies.	Introduction and improvement of techniques used (to abstract the water from the source, to convey it from the source to the irrigated area, and to apply it to the crop);
***Source:* Report Compilation from RBA assessments and other sources.**	
Notes: [1] Ethiopia RBA Report. [2] Kenya is allowing too short a period for this – 6 months – and experience elsewhere has shown that 1-2 years for effective establishment is required with targeted follow up for up to 5 years and then extension support thereafter.	

3.2 What does improved efficiency mean and what will be the impacts?

Efficiency in water use has different meanings to different people. For engineers and technicians involved in the operation of irrigation and drainage systems and the delivery of water to the farms, efficiency tends to mean technical efficiency (Operation; Conveyance; Distribution; Application) relating more to *service delivery*. For farmers, efficiency relates more to *on-farm water management* and the ability of the water delivered in meeting the crop water needs in terms of crop water needs. Over the last 10 years, greater emphasis has been placed on evaluation of water provided at the field against the amount of crop produced or in proportion to the evapotranspiration of the crop. This approach has been followed in this section of the report when water use and areas for improvement are discussed.

Large-scale irrigation (LSI) schemes[79] are aimed at production of food and industrial crops for meeting national markets and export needs. Even though many of the large-scale schemes within the Nile Basin are farmed on a smallholder basis, they are included in the LSI category due to the economy of scale, the way in which the crops grown are aimed at national rather than local markets and the ways in which the irrigation systems are managed and water is shared throughout the Nile basin. With the amount of water involved in large-scale irrigation schemes (canal capacities are often well in excess of 20 m^3/sec.), it is evident that improvement in water use efficiency, whether it is in terms of conveyance efficiency or what is actually provided for crop growth, can make a significant impact on the availability of water to other users further down the system. Experience in Egypt with rehabilitation and upgrading has shown that canal and application efficiencies can be increased by up to 20%. There will thus be transboundary implications and benefits from these interventions.

Small-scale/community irrigation schemes have different roles to LSI with most being aimed at increased food security for both the communities and districts in which they are located. In

[79] See section 2.3 below for definitions and discussion on scheme size

the upper Nile Basin countries[80], the proportion of farmers benefiting from irrigation is small with irrigation interventions being mainly classified as small-scale irrigation and with water diversion requirements being relatively small in the overall Nile context. Improvements in irrigation efficiency and water use will thus not result in significant amounts of additional water being available to downstream areas. Any changes that result will be absorbed by parts of the same systems that are either receiving insufficient water, or by extending the system to provide more benefits to a greater number of members of the community. Transboundary implications will thus be limited. Of continual concern to the Upper Nile Basin governments is the relatively small number of farmers who are currently benefiting from irrigation facilities. All would like to widen the sphere of influence of irrigation, but sources are limited and the cost of conveying water to potential areas can be high. Water harvesting fulfils this third role that will be aimed at improving the returns that small farmers get from their farming systems that are mainly rainfed, thereby contributing to household food security and poverty reduction. The impact and target group will very depending on the measures adopted, for example in-situ water harvesting techniques will have a direct benefit to rainfed agriculture and hence on poverty reduction.

3.3 Performance assessment[81]

Performance assessment of irrigation and drainage systems is aimed at assessing the extent to which the system is operating as planned and designed[82]. If the use of water for irrigation is to be improved, then current levels of performance must be understood and constraints and issues arising in the system identified, to enable measures for improvement to be proposed. Performance assessment can be carried out at two levels. (a) The first relates to scheme level and measures the extent to which target levels are being met at any specific time[83]. This requires information on intended objective of the system to be compared with actual measurements of the related outputs. (b) The second level relates to longer-term performance and the extent to which available resources have been utilised to achieve the broader set of objectives[84]. This links to longer-term goals and an examination of transboundary issues such as the need to revise the scheme objectives in light of the changing demands and wider basin issues.

The application of performance assessment procedures will vary depending on the purpose of the assessment and the type of scheme. Assessments needed for large scale irrigation schemes (LSI) that are centrally managed will differ considerably from small-scale/community managed irrigation schemes. In many cases, the former have a system equipped with measuring structures at division points whereas the latter often have no measuring structures. The ability to measure and assess the performance of these schemes will vary considerably and depend upon what can realistically be achieved and that will be good indicators of performance[85]. Measurements of canal discharge will provide information on how the irrigation and drainage network is performing (e.g. adequate and timely water supply), but provides limited information on system performance as a whole. To obtain such information, irrigated agriculture data needs to be collected from within the system as many variables intervene between the supply of irrigation water and the money received by the farmer for the crops produced. Baseline references are required for measurable items in order to monitor and

[80] Burundi, DRC, a Rwanda, Kenya, Tanzania, Uganda, Ethiopia.
[81] "A systematic observation, documentation and interpretation of activities related to irrigated agriculture with the objective of continuous improvement." – see **Glossary of Terminology.**
[82] Boss, M..G.; Burton, M. A.; Molden, D.J.; Irrigation and Drainage Performance Assessment, Practical and Guidelines; ICID & IWMI; CABI Publishing, UK
[83] *Operational performance*.
[84] *Strategic performance*
[85] For definition of indicators in use for LSI, see Agricultural Water Use and Water Productivity in the LSI's of the Nile Basin, Wim Bastiaanssen, Large Scale System Consultant, EWUAP.

evaluate improvements in water use efficiency. Currently few countries are accurately measuring the efficiencies of water use[86] or collecting system data that could be used to carry out the required assessments with most information presented being subjective. Some indicators that can be measured include:

- Water use volumes (m^3/ha; m^3/crop in relation to consumptive use);
- System efficiencies (conveyance; distribution; operational; application);
- Water distribution equities (flows of water provided per hectare for different parts of an irrigation system);
- Crop yields (kilograms per cubic metre);
- Farmer incomes (net returns per cubic metre of water; percentage of water cost to overall input cost of crop production);
- WUAS established (WUAs effectively functioning, collecting funds from members, planning O and M activities, funding O and M activities with O&M responsibilities fully transferred to WUAS and jointly assumed).

These data will set the performance of the irrigation system in context with performance measured through the use of indicators, for which data are collected and recorded. The analysis of the indicators then informs us on the level of performance[87]. For small-scale/community managed irrigation systems, typical performance indicators and criteria are given in Table 4.2 below[88].

Issue/Constraint: *Insufficient information are available on the performance and details of existing small and medium scale irrigation developments in the Nile Basin. Priorities for support resulting from the greatest potential for increasing productivity need to be established.*

Criteria for scheme performance considering small-scale/community managed irrigation systems and water harvesting, will depend upon the viewpoint (Table 4.3[89]). Under EWUAP, the intention is to identify *Best Practice*[90] within the Nile Basin and by *Benchmarking* of the identified scheme(s) with other scheme(s) exhibiting good performance Best Practice within the countries and the Nile Basin can be identified.

[86] The LSI Consultancy is establishing methods for collecting data for LSI schemes and it is hope that the same methodology could be applied at a later date to CMI schemes.
[87] The linkage between the criteria against which performance is to be measured and the indicators that are to be used to measure attainment of those criteria, is important.
[88] Performance criterion, such as equity can be defined differently depending on the system to which it relates.
[89] Adapted from Chambers, 1988
[90] A *Best Practice* is a good example of what can be achieved in Irrigation and Drainage or Water Harvesting and can be used for Benchmarking of systems as well as providing models for wider dissemination. The EWUAP workshop on best practices defined it as "*One that gives optimum utilization of land and water resources for sustainable agricultural production and environmental management*."

Table 4.2 Typical Linkages between Performance Criteria and Performance Indicators[91]

Criteria	Performance indicator[92]		
	Irrigation and drainage system	**Irrigated agriculture system**	**Agricultural economic system**
Command	Water Level Ratio Delivery performance ratio Water use efficiency	Cropping intensity Overall product efficiency	-
Adequacy	Overall Consumed Ratio Delivery Performance Ratio	Crop production relative to family food needs	Cash value of crop production relative to defined poverty level
Equity	Overall Consumed Ratio Delivery Performance Ratio	Spatial distribution within scheme of crop type/crop yield & cropping intensity	Spatial distribution within scheme of farm income
Reliability	Overall Consumed Ratio Delivery Performance Ratio	No of years crop production is adequate	No of years income from crop production is adequate
Efficiency	Conveyance efficiency Distribution efficiency Field application efficiency Irrigation system efficiency Outflow over Inflow Ratio	Crop yield Depleted fraction	O&M Fraction
Productivity	-	Crop yield Land and water productivity	Crop Gross Margin Internal Rate of Return Productivity of water ($/m^3)
Profitability	-	-	Farm Profit Return on Investment (EIRR)
Sustainability	Efficacy of Infrastructure Groundwater depth Indicator Value on Salinity	Sustainability of Irrigable Area	Financial Self Sufficiency O&M Fraction Fee Collection Ratio

Notes: Adapted from Boss, M.G.; Burton, M. A.; Molden, D.J.; 2005.

Table 4.3 Criteria for good scheme performance

Type of person		Possible first criterion of good system performance
Farmer	:	Delivery of an adequate, convenient, predictable and timely water supply.
System Management	:	Efficient delivery of water from headworks to the tertiary outlet.
WUA Committee	:	High and stable farm production and incomes.
WUA Advisors/Extension Staff	:	High internal rate of return (capacity to meet costs and to provide sustainable income especially for disadvantaged groups).
Govt. Planner or Macro economist	:	Equitable distribution of benefits; reduced burden on State.

[91] In the service delivery contexts, the degree of control available at the following points is important: (a) Abstraction (headworks); (b) Conveyance and distribution (canal network to farm); (c) Application (on-farm); (d) Removal (drainage system/network).
[92] See Glossary for explanation of definitions.

3.3.1 Condition of Irrigation Infrastructure

Many of the community irrigation and drainage systems within the Nile Basin are underperforming due to the poor condition of the infrastructure. Over time, this has deteriorated badly due to insufficient past investment and a lack of involvement of the beneficiary farmers in the operation and maintenance of the systems that they use. A heavy focus on visible physical works with inadequate attention to farmer participation and involvement resulted in insufficient clarity on the division of responsibilities for management between government and farmers. Such over sights have been typical of the organizational culture of government-led small-scale irrigation development with farmers failing to identify with the systems that they are being asked to take over and operate. More effort is required to ensure that effective WUAs are established and that they are trained, able and willing to take over much of the O&M of the systems with charges levied related to the ability of the farmers to pay.

3.3.1.1 Asset Management

Irrigation and drainage infrastructure consists of a large number of individual **assets** including dams, canals, control structures, pumps, drains and other facilities that are dispersed over wide areas. As the system deteriorates, the productive potential is lost and inequity in water supplies and availability results. Water deliveries become less reliable and crop production declines. Typically tail-end farmers suffer most as systems and this has been one reason for an increase in the reuse of drainage water in some countries. To ensure that systems are maintained to the required level with sufficient recurrent expenditures dedicated to annual MOM, a new asset management approach is needed with irrigation and drainage assets being treated in the same way as other assets of national importance.

Asset management has been defined as follows: 'A structured and auditable process for planning, implementing and monitoring investment in the maintenance of built infrastructure to provide users with a sustainable and defined level of service.'[93] The level of maintenance performed on assets determines the life and poor maintenance standards reduce this and the ability of assets to perform their intended function. The need for comprehensive maintenance records is critical as it permits an O&M analysis. By integrating maintenance records with an asset database, management can quickly access information on the performance of individual assets, the current costs and estimate future maintenance requirements. These are critical for keeping a clear record of completed maintenance works and infrastructure performance as well as determining appropriate replacement times. The case of the Government of Kenya illustrates the needs and benefits (see box below).

The need for an Asset Management Approach

The Government of Kenya is planning a program of modernization and improvement of irrigation schemes. This will include rehabilitation and upgrading of existing I & D infrastructure. Rehabilitation costs more than regular maintenance, both in financial terms and in terms of resources used, and thus any investments made for this will require a clear strategy in relation to a/. the interaction between the WUAs and government, b/. the works to be undertaken and c/. the specific detailed O&M activities (routine and preventative) that will need to be undertaken once the rehabilitation and modernization works have been completed. For this to be effective, government needs to establish a strategy that is based on an assessment of the status and condition of the infrastructure at a given reference point and using this determine how it would like it to be managed and maintained in the future so that government financial support is minimised. Asset management is the obvious tool for this process, particularly as the processes involve close discussion and involvement with the WUAs, the beneficiaries and users

[93] Guidelines for the Preparation of Asset Management Programs for Irrigation and Drainage Systems, ICID, Moscow 2004

As custodian of the irrigation and drainage systems, governments needs to ensure that the WUAs, as delegated managers and operators, maintain the facilities to a certain standard. Experiences gained from World Bank financed projects have shown that if WUAs/farmers are put in the driving seat when assessing rehabilitation needs, they adopt a more positive system of prioritization that involves a series of targeted spot improvements rather than a blanket replacement approach. To achieve this, government needs to advise and intervene if they see that the systems are being neglected. The levels to which this is required need to be clearly set out a Transfer Protocol between governments and the WUAs[94]. Irrigation ratios, the proportion of commanded land to actually irrigated land, will show wide variations between different parts of the countries, reflecting the varying capacity of water users associations in different countries and regions to manage the systems as well as collecting sufficient funds or gaining sufficient returns to be able to collect the levels of funds needed for asset management to be effected.

Key Concern: *The failure on the part of government to define clearly the requirements and obligations with respect to asset management will result in the 'mining' the value of the assets by communities or WUAs who, together with government, have failed and are continue to fail to invest sufficiently in the infrastructure over time, leading to failure of the system in the longer*

3.3.2 System Management

To reduce the burden on government and to ensure sustainability of investments, governments have embarked upon the process of Irrigation Management Transfer (IMT). This covers all scales of irrigation schemes from small (see 2.3.1) up to large-scale developments in Egypt under the Irrigation Improvement Project. The model used in many cases has been developed in Asia and more efforts are needed to ensure that the approach adopted in Africa is based on experiences there, with adequate attention paid to management skills and the history/knowledge of irrigation. Details on how this transfer process is being carried out in each of the riparian countries are not complete. However, it is clear that appropriate methodologies need to be developed for use in the Upper Nile basin countries which comprise smaller scale schemes than those in the lower Nile Basin (Egypt and Sudan). This should include clear guidelines and training materials prepared for the staff. Direct transfer without supporting improvements and upgrading of the systems to meet the needs of the farmers and farmer management has been shown to produce unsustainable results. In a number of the countries (such as Ethiopia) the transfer from government to user management and O&M accounts for much of the poor performance of the schemes.

Considerable savings in government O&M budget will result from IMT with permanent staff numbers falling. This reduction in government staff and the transfer of responsibilities will not be without its problems, especially in less developed regions of the Nile Basin, where farmers are resource-poor, are often traditional agro-pastoralists with limited experience of irrigation, and where climatic conditions are less suitable for irrigation, growing periods are relatively long, markets for crops are not so well established and communications less well developed.

Issue/Constraint: *The prevailing institutional problems are (i) institutional instability (in the irrigation sector) and (ii) the irrigation management aspect is not adequately addressed in the organizational structure of the government agencies.*

[94] It is not reasonable to expect WUAs to achieve the "required standard" when this has not been defined and when continued and appropriate training and support are not provided regularly and in as structured plan.

The improvement of the community managed schemes rests with the full involvement of communities at all stages of the interventions and with management handed over systematically - management at the appropriate level. It may be that some communities will never be able or willing to manage the main and secondary conveyance systems, and this should not be forced upon them in such cases. Lessons learnt in neighbouring countries in the establishment and involvement of the farmers in the WUAs and their empowerment need to be examined and exchanged with farmers being involved to a much higher degree so that they regard the systems as theirs. This should be carried out at the appropriate level, so that unjustified assumptions on their ability and willingness to take over the system are not made.

Issue/Constraint: *Inadequate farmer participation, focus on physical works, and insufficient clarity about the status of the systems and responsibility for management have been typical of the organizational culture of government-led small-scale irrigation development in the country – Tanzania.*

All improvements planned for existing schemes must include not only structural improvements, but training and measures to improve irrigation efficiency and water management. Such measures coupled with establishment and training of farmers through their IOs, will double efficiencies and treble yields. Size of irrigation scheme in many cases will determine the level of service that can be provided to the scheme farmers. Governments need to consider area in relation to WUA to determine if it will be able to provide a comprehensive MOM service for its members without government assistance. The size of WUA operational areas influences their performance. If smaller organisations can be combined, they are able to hire/access professional advice and acquire appropriate O&M machinery in a more cost effective manner. This may not always be possible due to geographical locations and other social or technical reasons. Care must be exercised when handing over infrastructure to the less well organised, smaller and not so well equipped WUAs as much of the larger I & D infrastructure may well be beyond their capacity for MOM.

On handover of responsibilities, government and WUA need to sign a protocol that outlines the scheme characteristics and makes explicit reference to any unfinished parts. Details of any sections of the scheme that may not be functioning due to wear and tear or poor designs/careless workmanship in construction, need to be provided. In such cases, commitments from government to complete the additional works at a later time after handover, but within a maximum period are need for users to take it over the scheme ‘as is’ for the time being. Time-scales must be set for these repairs/improvements otherwise government will not actually rectify shortfalls. The agreement will also state that I & D infrastructure needs to be maintained in the “required condition” at handover, and this level must be defined, as there is no common standard due to the age of some of the systems.

Although after transfer, operation, maintenance and repair works are the responsibility of the WUA, oversight responsibility for ensuring that this is carried out to established standards is retained by government. The mechanisms, requirements and the range of tasks to be undertaken by the WUA in the O&M of the facilities will be spelt out in the transfer protocol that states what should be done in the case of a failure of the WUA to fulfil its stated obligations. Sanctions and means for ensuring that the maintenance costs can be recovered should government have to intervene and undertake the works will also be included. To meet these obligations, government needs to ensure that inspection teams prepare annual maintenance reports at the end of each main irrigation season, following joint inspections of each irrigation scheme whether transferred or not. These provide the basis for the following year’s programme of maintenance works for the WUAs, with the costs determined by government staff using their own procedures and unit rates, and forms the basis for target budgets for the WUAs. Experience has shown that WUAs generally do not raise sufficient required budgets with outstanding works deferred to the following year. Unless addressed by government, further accumulation of deferred maintenance works will accrue.

The initiatives undertaken by RBMSIIP in Tanzania[95] have shown the importance of linking improvements to existing irrigation developments to achieve greater efficiencies in water use. This covered the wider issues of water allocation and sharing, conflict resolution and basin wide issues such as the meaning of water rights and the training of farmers to visualise the amount of water that relates to their allocation. Provisions in the designs for improved drainage return of excess flows to the rivers and periods of intake closure all reassured other users and enabled them to see the real benefits of the adopted approach. These experiences from this successful approach should be extended to other catchments and sub-basins with the Nile Basin countries to ensure that each user has a water right based on historical performance and agreed needs. Users should be required to obtain a licence for this with water user fees determined in line with government policy. If the RBMSIIP experiences are utilised and farmers see the need for improved water management on their schemes, then it will then be possible to allocate a proportion of the additional benefits to meet the costs of charges/fees from the users and to make a start on addressing inefficiencies.

One important lesson from the RBMSIIP supported studies into the Usangu wetlands was the need to provide separate drinking water within the larger irrigation command areas. Currently most schemes rely upon the canal water for many of the daily household uses. Thus, even if irrigation is not required, canals need to flow. If separate water supplies for the communities are provided in the schemes using water harvesting techniques and boreholes, then irrigation supplies to the schemes can be closed at the headworks when not required. This will have substantial environmental and basin management impacts for downstream users and will also facilitate the seasonal system maintenance of the schemes.

3.3.3 Incentives for Change

Unless measures are put in place to encourage water users to improve their water use efficiency and productivity, little change will take place. Training and awareness of the approaches to be encouraged and followed need to be established and one effective measure has been the gradual introduction of river basin and water charges. In addition to this, investments are needed in the irrigation infrastructure that enable higher yields to be achieved and returns to labour increased accordingly. Experience in Tanzania has shown that agricultural productivity and irrigation efficiency can be raised simultaneously[96]. This was achieved through investments in upgrading small-scale irrigation schemes using participatory methods of approximately US$ 2,000/ha. When coupled with adequate agricultural advice, these levels of investment can bring a measurable improvement in the welfare of smallholders at acceptable rates of return. Limited but targeted investments in irrigation and drainage infrastructure improvement can also provide an adequate incentive in terms of increased productivity as a "carrot " to encourage farmers to reduce water wastage and to consider the water demands of other users.

With the higher returns that accrue to irrigated agriculture, farmers should be in a better position to pay for services provided by the private sector. These do not necessary have to involve monetary payment, but could involve a share of the increased crop yield – a system used in other parts of the world to pay water masters. If the extension staff are good at their tasks, yields and hence their payments, will be high. Successful approaches for achieving this still need to be pioneered and in the short term, incentives and guidance will still be needed to

[95] World Bank. (2004). Implementation Completion Report. On a Credit for a River Basin Management and Smallholder Irrigation Improvement Project (RBMSIIP).
[96] Implementation Completion Report (ICR) for the River Basin Management and Smallholder Irrigation Improvement Project (RBMSIIP).

motivate staffs who require training manuals and guidance for the farmers. It is hoped that once established, farmers will see the benefits of advice on water harvesting and this could be supported through service providers from the private sector. Extension services being replaced by NAADS (National Agricultural Advisory Services) which has long term goal of privatising extension services. The transmission is not smooth and leaves a lot of gaps. Most farmers are still basically subsistence farmers and can not afford private services.

3.3.3.1 Water Pricing

Pricing for water needs to be based on estimates of the amounts of water consumed. For potable, industrial users and modern irrigation schemes direct measurement is possible. For most traditional irrigation schemes in the Nile Basin, volumetric water measurement at main canal offtakes is possible but not carried out, but within the schemes usage can only be estimated. In Tanzania, suitable structures have been incorporated in all rehabilitated and upgraded schemes with charges being levied on the irrigation organisation based on agreed cropping patterns and efficiencies of use. These efficiencies must be taken into account when considering traditional irrigation schemes and form the basis for encouraging greater productivity per unit of water. Farmers are prepared and can pay for water provided that the reasons are explained to them and they are assisted in achieving increased outputs that enable them to cover the higher costs demanded of them. Fairness across user groups must be assured with reasonable time frames established, as changes cannot be introduced over night.

Issue/Constraint: *In a number of Nile Basin countries, insufficient thought seems to have been given to the ability of farmers to pay for water charges. The approach promulgated by potable water supply planners whereby users of either irrigation or drinking water pay the same does not comprehend the needs of the poor rural communities and marginalises the most vulnerable farmers who cease to irrigate.*

Where charges are prepared on the basis of volumetric water use, as is the case in most countries, these will be difficult to quantify in almost all CMI schemes that lack means of flow measurement. In addition, it seems unreasonable to penalise communities who have developed their own irrigation schemes using their own resources but that are inherently inefficient as these farmers are often resource poor. Charges for water use in Kenya have recently been gazetted and amount to $0.0076/m^3 for irrigation water for the first 300 m^3 and $0.0114/m^3 for volumes larger than 300 m^3. While this is at the high end of expectations, these charges could assist as a driver for more efficient water management at the scheme and unit level. However, experience around the world[97] has shown that water scarcity is a much greater driver than water pricing. The latter tends to put the poorer farmers out of business when they get to a certain level, whereas restricting the peak supply of water and forming the farmers into cohesive and efficient water users Association, makes them take important decisions on how they apply and deliver water to their own members. By putting the price is too high, i.e. reflecting the opportunity cost of the water; aspects such as ability of the poorest section of farmers to pay are ignored. It is important to recognize the importance of irrigation in feeding and employing the poorest members of community, rather than letting them rely upon handouts and direct government support. It also keeps them in the rural areas instead of driving them to the urban areas in search of employment. Other than Kenya and Tanzania, no irrigation water charges are in place within the upper Nile Basin. In Ethiopia charges at the Awash Valley irrigation farms in the neighbouring Awash basin are set at 3 ETB per 1000 m^3 (US$ 0.0003/m^3) of water.

[97] Cornish G., Bosworth B., Perry C., Burke J., Water charging in irrigated agriculture An analysis of international experience, HR Wallingford Ltd. FAO Water Reports, no. 28.

Water harvesting considerations are rarely included in the preparation of water charges for irrigation and drinking water supplies. For these interventions, incentives to farmers and others to invest time and money and thereby reduce the pressure on the formal water supply systems are needed. There would seem to be clear justification to enact a system of negative charges for water harvesting and if these are set at a suitable level will both encourage communities to develop water harvesting systems as well as maintaining them. In addition to this, where farmers have invested in systems in the past, it seems unreasonable to ask them to now pay water charges. These aspects need to be clarified and elaborated upon in all Nile basin countries.

3.3.4 Improvements in Productivity[98]

Only Egypt and Sudan are currently thinking in terms of crop water productivity. Many governments are considering improving the efficiency of water use, but these tend to be approached from the conventional engineering point of view related to physical efficiency of conveyance systems rather than considering what is produced per unit of water delivered. In Sudan where water is a severe constraint and agricultural production is considered to have low productivity, attempts have been made to assess the factors that are influencing productivity as well as the results achieved. According to the Agricultural Research Corporation in Sudan, the main reasons for low productivity are:

- Poor land preparation
- Very late sowing
- Use of low yielding varieties
- Poor disease and pest control
- Use nil or minimal fertilizer
- Poor management of irrigation water

Crop water productivity for the main crops in Sudan has been examined in terms of their definition of water use efficiency[99] (WUE) to determine the impact over a five-year period up to the cropping season 2006/2007[100]. The approach covers both rainfed and irrigated crops and, as water measurements made are limited, this will provide only the first step in assessing crop water productivity. Although there was a slight increase in WUE for cotton over the 5 year study period, in most cases it was small. In northern Kordufan, where productivity is generally low and rainfall variability high, a fall in WUE was been recorded. Sorghum is a predominantly a rainfed crop and data presented in the Sudan RBA report shows a direct correlation between yields and rainfall confirming this. However, in the WUE study in the traditional rainfed areas, a slight increase was recorded with larger increases in those areas where mechanical production was used. The most marked change is in the irrigated areas where the impact of rainfall variability has been considerable reduced. In these areas, significant increases in water use efficiency have been achieved. WUE varies strongly with climate and in those areas in central Sudan that use more water and produce less, a more favourable water use efficiency of 0.78 kg/m^3 was found compared with 0.5 kg/m^3 in the northern states [101].

Maize is more popular in the southern states of Sudan where it is also grown for fodder. Productivity is low mainly because of the traditional varieties that farmers use. Where it is grown in other states, higher values of water use efficiency were achieved. Sesame is grown mainly under rainfed conditions for export and local consumption. No significant change in

[98] See definitions in the Glossary at the start of this report.
[99] The ratio of economic yield to effective rainfall and/or irrigation.
[100] Rapid baseline assessment, Ahmed Ali Salih, national consultant for EWUAP, Sudan, August 2007.
[101] It is interesting to note that the difference between wheat varieties were not considered significant when determining WUE and that WUE increased significantly when one irrigation was skipped during early plant growth raising the WUE values to 0.81 kg/m^3 and 0.49 kg/m^3 respectively.

WUE has been recorded over the five-year period. The same is true of millet which is a staple food for most population in the western states. Only small areas of rice are grown and these are located in the White Nile state. Since 1997, productivity has been gradually increasing to reach a peak in 2004. This has now dropped off and has remained more or less constant at about 0.66 kg/m^3. For sugar cane which is a significant export for Sudan and which is produced in five sugar plantations, a WUE of 2.5 kg/m^3 for cane is achieved.

Many communities blame the lack of productivity on the lack of information, knowledge and skills concerning better methods of food and income-generation (crop production, animal husbandry, fishing methods and alternatives), soil conservation, pest and disease control, marketing opportunities, prices, processing and pertinent government policies and regulations. High marketing margins on agricultural produce and inadequate allocation of budgetary resources for the supply of appropriate inputs encourages the low input/ low-productivity model of production that continues to prevail, and small farmers' incomes remain depressed. The loss of 35-40% of crops to disease and pests severely limits productivity of both food and cash crops – cassava, coffee, banana, tobacco, groundnuts and cowpeas. Poor farmers are unable to cope with diseases and pests because of a lack of money, limited availability of drugs and pesticides, lack of or misguided advice, conflict with Government regulations and officers. There is also poor adoption of technical packages for production and farmers have insufficient information on crop management packages (improved seeds, fertilizer, pest control, cultural practices, harvest and post-harvest) under both rain-fed and irrigation conditions; and maintenance of soil fertility essential for sustainable production.

Constraints to increasing productivity, achieving food security and reducing poverty cannot be addressed in isolation. Overall poverty reduction must be based on approaches that link agriculture and other sectors - institutionally, organisationally and operationally at all levels from the farmer up to the centre. Clearly, there are policies and programs designed and implemented outside the agricultural sector that will impact upon the success of interventions in the agricultural sector and may impact upon improving the well-being of subsistence farmers. Increased productivity, heightened food security[102] and low food prices, means reduced expenditure on food. These savings can be spent on products from other sectors such as manufacturing and services, which in turn leads to expansion of employment in these sectors. Increased growth in off-farm employment will eventually lead to a reduction in the percentage of the labour force employed in agriculture. Higher incomes, both on- and off-farm will stimulate activities in trading, processing, marketing and transport throughout the economy contributing to general economic growth. A transformed agriculture leads to more active land markets and increased efficiency of land utilisation. All contribute to a radical transformation of the rural economy.

Improved irrigation systems to provide acceptable levels of service and improved on-farm water management will be key factors in the raising of productivity. The most cost effective means of developing irrigation is through the rehabilitation and upgrading of existing developments. This requires a two pronged approach. Improvements to the main and secondary conveyance system tend to require investments in physical improvements with attention paid to efficient flow and minimising losses, ease of flow measurement and operation, and improvements to management and communication to ensure that water is delivered as and when the users need it and in the quantity that they require. At the tertiary level and below, improvements need to begin with the establishment of effective and sustainable water users groups. They need to be empowered so that they are in control of both of the delivery of the water as well as the utilisation of the same within the command area that

[102] Food security is generally defined as the *ability to provide adequate food for the household throughout the year, whether through adequate food produced by the household or by households earning enough incomes to be able to purchase food on the open market.*

they manage. Improvements within these lower parts of the system must be channelled through the water users groups with assistance provided to the physical infrastructure coupled with training in the management, operation and maintenance (MOM) the system. Continued extension support is essential in the improvement of farm practices that include reduction in excessive water applications, the staggering of planting and harvesting dates, the cultivation of crops that provide sufficient returns to enable the farmers to meet additional charges as well as providing adequate incomes for their families, and the development of market linkages to promote value-added production.

Governments want to reduce the migration of rural population, especially the youth, from country to town. This can only be achieved if both existing productivity in the rainy season is increased and made more reliable, and if the returns to dry seasonal casual labour exceed the opportunity cost of alternative casual urban or construction employment. With the changing and highly unpredictable rainfall patterns, the absence of access to reliable irrigation water supplies for agricultural production makes intensification as a growth strategy a risky if not losing proposition. For the smallholder farmers, the use of fertilizers for rainfed crops is on the decline as they are proportionally very expensive for them and in many cases they borrow to purchase. If rains fail then they suffer both from lack of production as well as from cash losses or increased indebtedness. If farmers have both irrigated and rainfed land, they will make their investments in fertiliser for the irrigated rather than the rainfed. They are thus more likely to achieve the projected yields than they will for rainfed land through their risk aversion measures.

Part III: Best Practices and Best Practice Sites in the Nile Basin

Under EWUAP, the intention is to identify Best Practice within the Nile Basin for wider dissemination of ideas and technologies to other countries with similar climatic and operating conditions. This requires a level of Benchmarking (see section 3.3) of the identified scheme(s) exhibiting good performance with other scheme(s) within the countries to define aspects for improvement and/or modification. In Part III of this report, Best Practices (BP) for irrigation and within the Nile basin are established. Initially the types of Best Practice for Water Harvesting and Community Irrigation are discussed and then the sites that have been identified by the National Consultants in the Best Practice studies are presented. The contents of this chapter will lead into Phase 2 of the EWUAP studies where common Nile Basin guidelines for design and implementation of water harvesting will be produced using the substantial amount of information that already exists within the Nile Basin countries.

.4 BEST PRACTICE IN THE NILE BASIN

4.1 Introduction

The definition of best practice varies according to the purpose to which it is to be put. In general the concept of best practice in the areas of interest of EWUAP relates to five main issues:

- Technical
- Economic
- Social
- Management, Operation and Maintenance (MOM)
- Institutional

Interventions relating to irrigation and water harvesting are often well planned, but have experienced problems related to the above during implementation. Intended benefits have often not been achieved in a timely manner. The EWUAP approach aims to identify sites that may not fulfil best practice in all aspects, but provide good models in some if not all of the above. When examining an area the size of the Nile Basin as well as dealing with the ten member countries, it is important to have a reasonable consensus on what are considered as best practices and to establish common criteria for identifying and profiling them. A *Best Practice* is a good example of what can be achieved in Irrigation and Drainage or Water Harvesting and that can be used for Benchmarking[103] of systems as well as providing models for wider dissemination. The EWUAP workshop[104] on best practices held in Nairobi at the end of November 2007 defined it as "*One that gives optimum utilization of land and water resources for sustainable agricultural production and environmental management*."

It cannot be expected that all aspects of a particular site will be regarded as *Best Practice,* but there should be sufficient impact that overall, the lessons and experiences of the site could provide examples to others. In the working sites in each Nile Basin country, there will be elements from which others can learn and on which the particular site can build on to improve the remaining aspects of the site. For example, the *Best Practice* of a particular scheme or site

[103] Benchmarking seeks to compare the performance of "best practice" schemes with less well performing schemes, and to understand where the differences in performance lie. Bos, Burton & Molden, Irrigation and Drainage Performance Assessment, CABI, 2005.

[104] Inception Workshop, The Identification, Selection and Description of Best Practices, Best Practice Sites and Centres of Excellence In Water Harvesting, Community Managed and Public/Private Managed Irrigation, Lenana Conference Centre, Nairobi, Kenya, 27 – 28 November 2007.

may encompass good organisation and management, but obtain poor prices and returns. This may be due to external factors such as limited markets for produce, poor access to markets (poor infrastructure) or internal factors such as relatively high production costs due to poor irrigation infrastructure, high payments to meet of O&M charges, repayments of past investments or for meeting water charges. The attributes that Water Harvesting and Community Irrigation Systems should exhibit are given in Table 5.1.

Table 5.1 Attributes required by Best Practices

Water Harvesting	Community Irrigation systems
Good example to be applicable to other areas	**Good example to be applicable to other areas**
Has wider applications to other areas (and sites) either in similar environments (AEZ) or in general terms when concerning management/institutional aspects (=>Replicability)	Has wider applications to other areas (and sites) either in similar environments (AEZ) or in general terms when concerning management and institutional aspects (=>Replicability)
Widespread community acceptance and support	Widespread community acceptance and support
Consideration of communities' interests living up/downstream of site.	Consideration of communities' interests living up/downstream of site.
Politically acceptable in a bid to influence funding.	Politically acceptable in a bid to influence funding.
Environmental friendly to ensure the conservation of the same.	Environmental friendly to ensure the conservation of the same.
Replicable to other areas with similar environment (AEZ)	Number of people and animals benefiting
Must be simple to operate and maintain	**Simple and good design**
Easy to set up	Simplicity of the design
Technology - easily adaptable	Appropriate topographic location
Should use local material as a priority	**Replicable to other areas with similar environment (AEZ)**
Easy to set up & beneficiaries easily trained in technologies	Must be simple to operate and maintain
Technology has wider replicability/market potential to keep costs low	Beneficiaries can be easily trained in technologies
Well adopted/owned by the local community	**Good level of System Management**
Owned, operated and maintained the community	Established Overall Management that provides good system O&M and is run by or well represented by beneficiaries.
Good level of community participation	Adopts Participatory approaches at all levels
Regarded as their own scheme	System for measuring water received and delivered to different parts of the system
Part/all of system managed/owned/leased by community	Sustainable use and proximity to water source
Efficient use of water	**Establish Users Management Group**
High percentage of Irrigated area.	Has established and function institutional set up with legal basis.
Conveyance/Distribution efficiency	Good planning of O&M with annuals plans produced and funded
Field application efficiency/ Water use efficiency	Established methods for collecting water charges and fees and with good level of farmer payment ratios
Good field/ on-farm water management (avoids over irrigation/ wastage, has system for policing & providing equity & reliability)	Good Financial management with transparency and accountability to Scheme organisation
Water productivity (kg/m^3; US$/$m^3$)	Monitoring and evaluation system established
Delivery performance ratio or Management performance ratio	**Efficient use of water**
Profitable	High percentage of Irrigated area.
Proven successful results with respect to agricultural production	Conveyance efficiency
Cost/Affordability - to poor investors-price equivalent to about three months gross disposable income	Distribution efficiency - Efficient and equitable water distribution system to the field
Provided income benefits to the local population	Field application efficiency
Must be profitable as business model with cost recovery in short time	Irrigation system efficiency
Technology durable with minimum maintenance in first 2 years	Overall product efficiency
Technology capable of increasing family income of target group by more than 100%	Good field/ on-farm water management (avoids over irrigation/ wastage, has system for policing/ providing equity & reliability)
Technology should use local available raw materials where possible	Delivery performance ratio or Management performance ratio
Cost-effectiveness (re benefits and number of beneficiaries)	Water use efficiency
Proven impacts on HH poverty reduction and family income	Water productivity (kg/m3; US$/m3)

	Good Agronomic Practices
	Improved agronomic practices (including IPM, crop spacing & nutrient management)
	Staggered crop planting with crop grown related to community and market needs and demand
	Understanding of crop water needs and productivity
	Good Post harvesting management
	Profitable
	Proven successful results with respect to agricultural production
	Established Market Linkages
	Provided income benefits to the local population
	Viable farming enterprises - Must be profitable as a business model with cost recovery in a short time
	Cost/Affordability - to poor investors-price equivalent to about three months gross disposable income
	Cost-effectiveness (re benefits and number of beneficiaries)
	Proven impacts on HH poverty reduction and family income

4.2 Water Harvesting Techniques and Best Practice

Rainwater harvesting is a simple and low cost water supply technique that involves the capturing and storing of rainwater from roof and ground catchments for domestic, agricultural, industrial and environmental purposes. When surface run-off is collected in reservoirs, it can be used for the meeting water demands in periods of low or no rainfall as well as for the management of floods and droughts. Surface runoff can also be used for recharging soil storage and groundwater replenishment that impacts positively on springs and shallow wells. Rainwater harvesting yields numerous social and economic benefits, and contributes to poverty alleviation and sustainable development.

Table 5.2 Definitions of Types of Rainwater Harvesting

Title	Abbreviation	Definition
Rainwater Harvesting	(RWH)	The control or utilisation of rainwater close to the point rain reaches the earth for productive purposes.
Domestic Roof Water Harvesting	(DRWH)	Utilisation of rainwater that falls on homestead roofs for water harvesting.
Non-domestic Rainwater Harvesting	(NDRWH)	Utilisation of rainwater for agriculture, erosion control, flood control and aquifer replenishment
Runoff		Water that may be harvested from roofs and ground surfaces as well as from intermittent or ephemeral watercourses.
Productive use		Includes provision of domestic and stock water, concentration of runoff for crops, fodder and tree production and less frequently water supply for fish and duck ponds.

The definition of water harvesting varies between organizations and users. In this assessment, Rainwater Harvesting (RWH) is the control or utilisation of rainwater close to the point that rain reaches the earth for productive purposes. This includes the provision of domestic and stock water, concentration of runoff for crops, fodder and tree production and less frequently water supply for fish and duck ponds. RWH can be further divided into Domestic Roof Water Harvesting (DRWH) that is the utilisation of rainwater that falls on homestead roofs for water harvesting and Non-domestic Rainwater Harvesting (NDRWH) that is the utilisation of rainwater for agriculture, erosion and flood control and aquifer replenishment. The types of system used are summarised in Tables 5.2 & 5.3.

Table 5.3 Examples of Non-domestic Rainwater Harvesting

Rainwater Harvesting	Main Characteristics:	Typical Examples
Micro catchments	- overland flow harvested from short catchment length - catchment length usually between 1 and 30 metres - runoff stored in soil profile - ratio catchment: cultivated area usually 1:1 to 3:1 - normally no provision for overflow - plant growth is even	Contour Bunds (for trees) Contour Ridges (for crops) Semi-Circular Bunds (for range and fodder)
External catchment systems	- overland flow or rill flow harvested - runoff stored in soil profile - catchment usually 30 - 200 metres in length - ratio catchment: cultivated area usually 2:1 to 10:1 - provision for overflow of excess water - uneven plant growth unless land levelled	Trapezoidal Bunds (for crops) Contour Stone Bunds (for crops)
Spate/Floodwater harvesting	- turbulent channel flow harvested either (a) by diversion or (b) by spreading within channel bed/valley floor - runoff stored in soil profile - catchment long (may be several kilometres) - ratio catchment: cultivated area above 10:1 - provision for overflow of excess water	Permeable Rock Dams (for crops) Water Spreading Bunds (for crops)

Water harvesting for productive uses can cover a wide range of different scenarios extending from individual household collection systems to diversion of seasonal flows for small and medium scale irrigation. The process is illustrated below in Figure 5.1. In the following sections, the techniques that can be used are discussed. The concept of best practice means that use of the technique does not guarantee best practice, but rather the selection of appropriate techniques with the community and the implementation to meet water needs in a sustainable manner that will ensure regular maintenance and full adoption by the communities.

Water harvesting is a proven technology to increase food security in drought prone areas. Erosion control and recharge of ground water are additional advantages. Rainwater harvesting requires a collection surface (either ground or a roof), a water guidance system (channels; pipes; guttering; etc) and a storage tank large enough to supply water throughout any gap between significant rainfall events. If that gap is a few days, the storage volume can be quite small. If the gap between rain events is a 'dry season' of several months, the storage volume has to be several thousand litres depending upon the productive use to which the water is put. The best technologies are the ones that can be afforded and managed by the beneficiaries and that utilise available local materials for installation and repairs and technical support for sustainability. The technology and sites should have good water use efficiency, be managed effectively, be properly maintained, be profitable, benefit the farmers and the community and have good environment management (water borne diseases, chemicals). A wide range of RWH systems are currently found in the Nile Basin although the full extent of their use is uncertain.

The major limitation in the design of water harvesting systems for rural areas is limited detailed rainfall data. RWH systems are always based on parameters with high variability. Rainfall and runoff are characteristically erratic in regions where RWH is practised. To compensate for this, estimates are required to ensure that safe levels of storage design derive. Even with clear guidelines, determination of the harvesting area is difficult and initial estimates may have to be adjusted considerably. Field experiences in these cases are important and lessons learnt must be utilised. Limited manuals exist at the moment to assist in the design and selection of storage available at the level of household or small group of houses although many organizations have their own procedures.

Water sources vary greatly across the Riparian countries depending on elevation, geology and agro ecological zone. The types of sources and suitability, primarily for drinking water are given in Table 5.4. It must be remembered that if communities have water close to the homestead, they will use it for drinking even if the quality is poor and there are potential health risks.

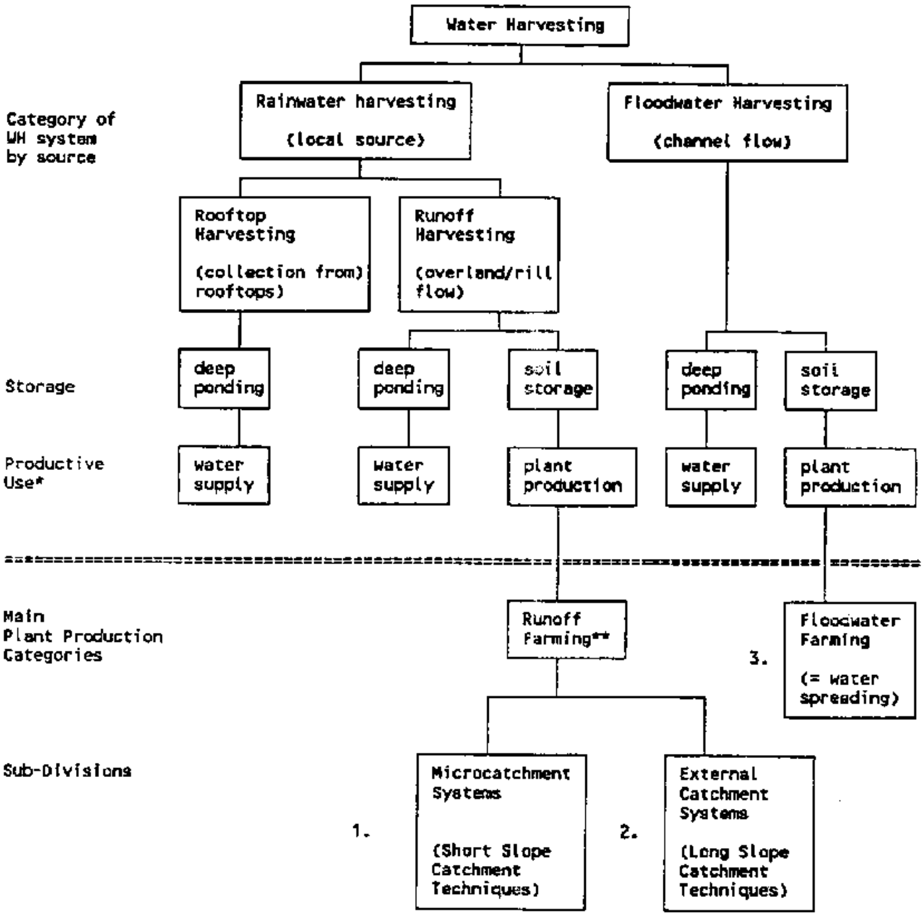


Figure 5.1 **Summary of Rainwater Harvesting Methods for Productive Uses**

Notes:
** Water supply systems (i.e. ponded water) used for a variety of purposes, mainly domestic and stock water but also some supplementary irrigation.*
*** The term "farming" (as in "Runoff Farming") is used in its broadest sense - to include trees, agroforestry, rangeland rehabilitation, etc.*

Table 5.4 Water sources and suitability

Water Source	Description
Borehole	Major reliable water source. These are however expensive when related to individual households and in many formations in Ethiopia are either too deep or produce water with high fluoride content. Safest and cleanest source; can have substantial queuing if located in or near town; water delivered only at certain times; cost levied; if queues are large rural communities obliged to purchase from water vendors; distance may be far; require donkey or two; if one donkey then two trips per day often needed (donkey carries two jerry to four cans);
Rainwater /roof catchment systems	Good source close to the households, but presents problems of collection and storage; Closest to home; very accessible; no abstraction cost; soft water; security of supply; The prevalence of thatch-roofed housing means that these are limited to community structures; Most community structures (schools, churches, mosques) are poorly constructed which means that gutters and down pipes will need replacing if they are to be used for water harvesting; Regular maintenance of the roofs and the roof collection system is needed otherwise the expected life of the whole system will be short. Small roof area did not permit harvesting of sufficient water;
Birkas/ Cisterns	Limited capacity; If catchment areas protected from animal and human excrement, can be used for drinking and other domestic uses; In areas where hard formation is experienced Birkas are favoured and where there is a clayey formation ponds or earth dams are used.
Pond/ Haffir/Valley Tank	Contaminated by surface runoff although animals precluded from entering; need desilting annually due to washed in sediment; communities can build themselves; abstraction difficult; an option for three to six months of water for both people and their animals, providing that water collection and abstraction is carefully controlled; water holding capacity can be very low due to the nature of soils. Little community involvement can result in low levels of pond protection and subsequent contamination.
Spring	Not available in many areas; often long walks and down steep inclines with difficult return journeys;
River	No cost at collection; often long distances; water not clean but communities often regard water quality lower than designers; can be more reliable than public system as can be accessed at any time; routine collection; pollution from animals etc. Shallow wells in some areas are found under the dry river beds

4.3 Structural Storage for Domestic, Livestock and Backyard Uses

Needs assessment for rural communities invariably results in drinking water as their top expressed need. Priorities for water use are set by each household and depend greatly upon the distance to the source at different times of the year (Table 5.5). It is not possible to isolate one use from the others. The important approach is to determine those related activities on which communities cooperate and those that they undertake on an individual or family basis. For the former, water collection for drinking and livestock is undertaken together although each household is responsible for their own containers and means for collection and carrying.

The basis for the water harvesting system is how much water is available to be stored, when it is available and how much will it cost. The volume of water stored will not only relate to available runoff that can be harvested but also to storage cost. Many techniques are available in RWH literature for determining the ideal size of storage tank for full water coverage throughout the year, but none exists for determining the size with modified consumption (during the wet season for example), or for partial coverage. This is an important consideration as rural farmers expect some inconveniences during dry years and are equipped for it. What they are not equipped for is the continual lack of water and the effect that this has on their limited assets. The aim in a design must be to reduce the burden on the rural communities in a pre-determined number of years so that the farmers can realise the benefit and can also replicate the system when more resources become available to them or their community.

Table 5.5 **Types of Water Use and the Appropriate Water Sources**

Water uses	Location of Use		Grade	Source
	House	Source		
Drinking	✓		1	1, 2, 3, 4, 5, 6
Cooking	✓		1 – 2	1, 2, 3, 4, 5, 6
Washing (Persons)	✓	✓	3	2, 5
Child birth	✓		1 – 2	1, 2, 3, 4, 6
Animal birth/ rearing	✓		2 – 3	1, 2, 3, 4, 6
Watering livestock		✓	3 – 4	2, 3, 5
poultry/ bees	✓		3 – 4	3, 4, 6
Washing (clothes)	✓	✓	3	2, 3, 5
Washing (dishes)	✓	✓	2 – 3	1, 2, 3, 4, 6
Tending the sick & elderly	✓		1 – 2	1, 2, 3, 4, 6
Religious observance	✓	✓	3	1, 2, 3, 4, 5, 6
Cleaning House	✓		4	
Agriculture/ Horticulture	✓	✓	4	2, 3, 5, 6
Potable Water Quality Grades	1	Good		
	2	Average		
	3	Poor		
	4	V. Poor		
	5	Unusable		
Sources of Water	1	Well		
	2	Spring		
	3	Open Pond/ Haffir/ Birka		
	4	Borehole – via Jerry can		
	5	River/Stream		
	6	Water Harvesting Tank		

The quality of the design solutions proposed for the rural communities is extremely important, but this must be accompanied by extremely good quality control of the implementation works. In Ethiopia between 2003 and 2005, many (~400,000) small-scale storage tanks were constructed that comprise mainly dug out ponds (50 - 180 m^3) for agricultural production. When built well with full involvement of the benefiting community, these tanks were successful[105] and adopted. When construction was poor and implementation costs too high in relation to benefits received, many were abandoned by the communities[106]. On average, only 36% of the tanks were considered operational in 2006, although some states (Tigray – 78%) had a much higher proportion working compared with others (SNNP – 15%)[107].

In determining the household consumptive use for drinking water, standards have been developed by WHO and adapted to local conditions. Suggested figures presented in Table 5.6 are for use in rural areas where minimal water is currently available at household level[108].

[105] When used for supplementary irrigation of high value crops the additional income to cash poor families enabled them to purchase between 50% and 100% of their annual food needs. (Landell Mills, 2004)
[106] Rapid baseline assessment, Ethiopia.
[107] MOARD, Ethiopia, 2006.
[108] In many rural areas of Ethiopia, present household consumption is around 5 litres per capita per day

Table 5.6 **Comparative Consumption data (litres per day)**

Category		Allowance (l/day)		
		Survival	Healthy Production/ Meat	Milk
1	People	10	20	
2	Cattle	25	30	35
3	Equine	20	25	
4	Sheep & Goats	5	10	15
5	Camels	50	55	
6	Poultry	0.15	0.25	
7	Pigs	10	15	

Storage Tanks can be divided into surface tanks (= above ground), underground tanks (including partly underground) and integral tanks (built into a dwelling). Most tanks have three clearly distinguishable parts, namely base, sides and cover. All three need to be waterproof. The base also needs to distribute the weight of the water evenly over the subsoil below. The sides (or walls) also usually have to support pressure forces from the water that puts them in tension. The cover has to span a gap while safely carrying such external loads as people standing on it. Tanks have a water inlet, sediment and debris trap, outlet, overflow, access hatch and often a means of drainage for cleaning. They must always be safe from sudden collapse and be durable. They are commonly required to be attractive looking, to have very low leakage, to protect water from natural or malicious contamination, to fit into the available space and be easy to operate (which may include easy cleaning out). Presented below are the relative merits of some common tank shapes (Table 5.7), the merits of tank placement (Table 5.8), and storage tank options (Table 5.9).

Table 5.7 Relative merits of some common tank shapes

Tank shape or type	Stresses	Material usage and construction
Cuboid	Stresses are unevenly distributed and difficult to calculate.	The ratio between material usage and storage capacity is lower than for a cylindrical and doubly curved tank. Construction is quite simple
Cylindrical	Stresses are more evenly distributed and are easier (though trivial) to calculate	There is an improvement in the material use to storage capacity ratio (a saving of 7.5% given a good height: diameter ratio). Construction becomes more difficult with traditional materials e.g. bricks.
Jar Style (doubly curved tanks)	Stresses are ideally distributed if the proportions of the jar are correct.	Material usage to capacity ratio is very good (savings of up to 20% over a cuboid) but construction can be very difficult, often relying on specialized moulds & techniques.

Table 5.8 Merits of Tank Placement

Location	Pros	Cons
Above Ground	Allows easy inspection for cracks and leakage; Water extraction by gravity; can be raised above GL to increase pressure.	Requires space; generally more expensive; more easily damaged; prone to attack from weather; failure can be dangerous.
Underground	Surrounding ground gives support; allows lower wall thickness and thus lower costs; more difficult to empty by leaving tap on; requires little or no space above ground; unobtrusive; water is colder; acts like a well.	Water abstraction more difficult; requires pump or long pipe downhill or steps; leaks of failures difficult to detect; possible contamination from ground waters, flood waters or bucket; danger for children and others if left open (drowning); animals can fall in if left open; surface wash contamination; heavy vehicles driving over or near can cause damage to cistern; cannot easily be cleaned;
Source: Adapted from DTU, Warwick University, UK. 2002.		

Table 5.9 Storage Tank Options

No	Tank Shape	Material	Location of tank	Type of Catchment	Volume stored (m^3)	Type of use
1	Hemi-spherical	Floor & walls: Cement – termite soil (1:6 ratio); roof any available material.	Below ground	Roof or Ground catchment	30, 50, 60 30, 50, 60	Livestock and crop production.
2	Hemi-spherical	Cement & sand mortar (1:3) for the floor & walls; roof any available material.			15	As Above + domestic uses, washing, homestead & crop production
3	Spherical	Top half: cement & soil blocks (1:4 ratios); Bottom half: cement & sand mortar (1:3).	Below or above ground		10, 30	Domestic drinking and washing Livestock and crop production
4	Bottle shaped	Concrete base (1:3:4); remainder cement & sand mortar (1:3).	Under ground		10, 30, 50, 60	Livestock and crop production
5	Dome shaped	Concrete floor & roof (1:3:4); remainder cement & sand mortar (1:3).			10, 30, 50, 60	
6	Dome shaped	Brick cap; walls: cement & sand mortar (1:3); roof; bricks; floor: concrete (1:3:4).				
7	Cylindrical	Ferrocement on concrete base.	Above ground	Roof catchment	10	Domestic drinking and washing and livestock
8	Cylindrical	Brick on concrete base.			10	
9	Cylindrical	Walls: Stone masonry or concrete blocks on concrete base.			10	

Cisterns are considered to be an important innovation to alleviate water problems in drought prone regions but their main limitation is the small storage capacity and relatively high unit cost. Such systems are now being developed not only for drinking, but also for homestead crop production, and are based on traditional practices used by pastoralists for many years (Birkas in Somalia Region of Ethiopia for example).

Harvesting water from rock catchments is very suitable where other water sources (groundwater and surface water) are absent or limited and where demand for agricultural land is high. They occupy unproductive hill slopes and acceptance of the system by the community has been found to be very high[109]. CARE (USA) has useful practical experience in the field that needs to be drawn upon. The first cisterns built between 1988 and 1991, were small in size (< 10 m^3). As demand increased, there was pressure from the community to construct larger cisterns and between 1991 and 1994; the size was doubled to about 20 m^3. After 1994, the design was revised several times and resulted in the adopted design of 100 m^3 capacity with reinforced foundation. This was found to be important as with time, foundation leaks and cracks were observed in some tanks. If site supervision is good and standard designs are used, the quality of construction is generally high and cistern operational and maintenance costs are small and within the capacity of the communities. All storage tanks were rectangular in shape, however, analyses of design[110], costs and construction techniques led to the adoption of circular tanks with 100 m^3 capacities. The major design constraint of the tanks was the limited detailed rainfall data. Determination of harvesting area is difficult and initial estimates were adjusted to give a catchment area/tank capacity ratio of 1.45:1 to 3.5:1 for Bosete Woreda and 4.5:1 for Adama Woreda.

The unit costs per litre of water stored when compared with other costs incurred by rural communities and farmers in water collection for domestic use indicated a payback time from 1-2 years. This did not consider the opportunity cost of the labour saved which could then be

[109] Anderson, I.M., Ethiopia, Small-scale Rainwater Harvesting Technologies, Assessment of Experience, World Bank. July 2002
[110] Some of the rectangular tanks constructed developed cracks near their corners.

used productively on other household income generating activities. Also excluded were the costs of animal transport[111]. In hilly country or where water point sources are widely spaced, 6-month pay back times are obtainable.

Cost considerations have been the major focus of recent research into water harvesting. Tank cost reduction can arise from (a) making tanks smaller, (b) using less materials (per litre of storage), (c) using cheaper materials, (d) using less labour, (e) using less equipment, or (f) 'sharing' materials between water storage and other housing functions such as walling. There is a considerable literature on optimising the sizing of RWH tanks but in practice, other decisions such as locally available material and expertise take precedence. If models are to be replicable and widely promoted, these two considerations are most important.

Along with checking the sequence of priorities, the planner must consider the cost and risk involved in providing alternate sources of water to water harvesting. The comparison must take into account the water quality required, operational and maintenance considerations as well as the initial cost. Where alternate water is of better quality, is cheaper to develop, easier to obtain or involves less risk, it should be given priority. An example of this is the development of springs or shallow wells for micro-scale irrigation, prior to water harvesting.

4.4 In-Situ Techniques and Gulley Control Measure

The techniques presented in Table 5.11 are not the only water harvesting systems known but represent the major range of techniques for different situations and productive uses. In a number of cases, the system which is described here is the most typical example of a technique for which a number of variations exist - trapezoidal bunds are a case in point. The Manual for the Design and Construction of Water Harvesting Schemes for Plant Production[112] from which this is taken is still valid in its approach and description and provides an excellent manual for those not familiar with the RWH techniques. It provides details of the main techniques (Negarim micro catchments, Contour bunds for trees, Semi-circular bunds, Contour ridges for crops, Trapezoidal bunds, Contour stone bunds, Permeable rock dams) and emphasizes that before selecting a specific technique, due consideration must be given to the social and cultural aspects of the community as these are of paramount importance and will affect the success or failure of the technique implemented. This is particularly important in arid and semi-arid regions of the Nile Basin where most of the population survive on subsistence regimes that resulted over the centuries in setting priorities for survival. Until all higher priorities have been satisfied, no lower priority activities can be effectively undertaken[113]. The techniques can be divided into micro catchments[114] and external catchments systems[115] (Table 5.10).

Within the Nile Basin countries, variations and additions to the above are used, but many are derived from the above and utilise the experiences from WFP[116], FAO[117] and the University of Berne[118]. One of the key aspects is the involvement and adoption by the farmers of the

[111] Donkeys cost about ETB 400-500 each depending on area. If water is not available, most farmers need to obtain an additional donkey for this purpose.
[112] Will Critchley; Klaus Siegert; FAO, Rome, 1991
[113] See Chapter 7 of this Manual where socio-economic aspects are discussed
[114] Within-Field Catchment System.
[115] Rainwater harvesting - Long Slope Catchment Technique
[116] Volli Carucci. 2000. Guidelines on Water Harvesting and Soil Conservation for Moisture Deficit Areas in Ethiopia: The Productive Use of Water and Soil: Manual for Trainers. WFP. Addis Ababa, Ethiopia.
[117] World Overview of Conservation Approaches and Technologies (WOCAT), AGL, FAO, Rome. (http://www.fao.org/ag/agl/agll/wocat/).
[118] WOCAT secretariat, CDE WOCAT, Hallerstrasse 10, CH - 3012 Berne, Switzerland. (http://www.wocat.org/)

techniques proposed and the regular extension support provided either by government or other organisations. In many cases the farmers who represent the target group for the measures proposed, are living on marginal lands with the returns from their work benefiting downstream users who have flatter lands with deeper and more productive soils. Many farmers questioned the benefit to them as the returns to their labours are often received 3-5 years later. As many of these farmers are resource poor, they are living on a much shorter timescale and although they could perhaps see the benefit of the measures, they cannot afford them.

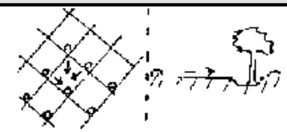
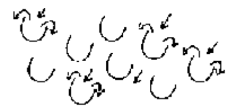
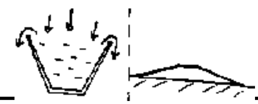
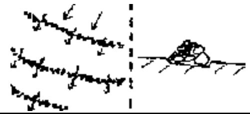
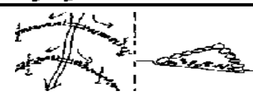
Table 5.10 In-Situ Techniques - Main characteristics

Micro-catchments	External catchment systems
overland flow harvested from short catchment length	overland flow or rill flow harvested
catchment length usually between 1 and 30 metres	catchment usually 30 - 200 metres in length
runoff stored in soil profile	runoff stored in soil profile
ratio catchment: cultivated area usually 1:1 to 3:1	ratio catchment: cultivated area usually 2:1 to 10:1
normally no provision for overflow	provision for overflow of excess water
plant growth is even	uneven plant growth unless land levelled
Typical Examples:	
Negarim Micro-catchments (for trees)	
Contour Bunds (for trees)	
Contour Ridges (for crops)	
Semi-Circular Bunds (for range and fodder)	

An integrated water harvesting approach is proposed as the methodology to achieve successful interventions. It is a best practice, but it is a composite of individual techniques[119]. If good planning procedures are followed together with full involvement of the communities, then such an approach should derive with catchment protection accompanying gulley control, good farming and in situ water harvesting, structural storage for drinking water and backyard crop cultivation, and downstream irrigation and water harvesting for livestock.

[119] For example in Ethiopia the best practices identified in the RBA report for in-situ techniques and gulley control are hillside terracing; trash lines; area closure for rehabilitation; multiple/intercropping; level bund with double stone walls; ridge & basin; Konso bench; stone bund; sediment storage dam; conservation tillage (CT).

Table 5.11 Various methods of water harvesting for Agricultural Development

	Classification	Main Uses	Description	Where Appropriate	Limitations	
Negarim micro-catchments	microcatchment (short slope catchment) technique	trees & grass	Closed grid of diamond shapes or open-ended "V" s formed by small earth ridges, with infiltration pits	For tree planting in situations where land is uneven or only a few tree are planted	Not easily mechanised therefore limited to small scale. Not easy to cultivate between tree lines	
contour bunds	micro catchment (short slope catchment) technique	trees & grass	Earth bunds on contour spaced at 5-10 metres apart with furrow upslope and cross-ties	For tree planting on a large scale especially when mechanised	Not suitable for uneven terrain	
semi circular bunds	micro catchment (short slope catchment) technique	rangeland & fodder(also trees)	Semi-circular shaped earth bunds with tips on contour. In a series with bunds in staggered formation	Useful for grass reseeding, fodder or tree planting in degraded rangeland	Cannot be mechanised therefore limited to areas with available hand labour	
contour ridges	microcatchment (short slope catchment) technique	crops	Small earth ridges on contour at 1.5m -5m apart with furrow upslope and cross-ties Uncultivated catchment between ridges	For crop production in semi-arid areas especially where soil fertile and easy to work	Requires new technique of land preparation and planting, therefore may be problem with acceptance	
trapezoidal bunds	external catchment (long slope catchment) technique	crops	Trapezoidal shaped earth bunds capturing runoff from external catchment and overflowing around wingtips	Widely suitable (in a variety of designs) for crop production in arid and semi-arid areas	Labour-intensive and uneven depth of runoff within plot.	
contour stone bunds	external catchment (long slope catchment) technique	crops	Small stone bunds constructed on the contour at spacing of 15-35 metres apart slowing and filtering runoff	Versatile system for crop production in a wide variety of situations. Easily constructed by resource-poor farmers	Only possible where abundant loose stone available	
permeable rock dams	floodwater farming technique	crops	Long low rock dams across valleys slowing and spreading floodwater as well as healing gullies	Suitable for situation where gently sloping valleys are becoming gullies and better water spreading is required	Very site-specific and needs considerable stone as well as provision of transport	
water spreading bunds	floodwater farming technique	crops & rangeland	Earth bunds set at a gradient, with a "dogleg" shape, spreading diverted floodwater	For arid areas where water is diverted from watercourse onto crop or fodder block	Does not impound much water and maintenance high in early stages after construction	

Source: FAO, 1991

4.5 Water Harvesting for Crop Production

The progress made on water harvesting at household level and the introduction of low cost simple trickle irrigation systems[120] has shown that considerable potential exists for using water harvesting for improving household food security. With storage volumes of 10 to 60 m^3 of stored water, it is possible for most households to grow sufficient vegetables for their own use and some for selling locally. The attributes and typical costs of various RWH systems are presented below (Table 5.12), and experience has shown that farmers are interested in the options available and do adapt to the technologies presented to them. The main times for water harvesting support to household crop production are:

- To overcome excessive drought intervals during rainy periods;
- To support vegetable crop production planted at the end of the rainy season and using both the last of the rains and residual moisture to become established;
- For complete crop support, aimed at the market shortages for higher value crops such as vegetables.

Table 5.12 Typical Costs and Attributes for Water Harvesting in Uganda

Water harvesting Technology/ practice	Use	Example Location of practice	Attributes					
			benefit	Acceptability	Cost	Spare parts availability	Technical support	Water use efficiency
Valley dam	Watering animals, domestic	Mbarara, Luwero	Water Time Health	Fair/ Poor	High $100,000 -200,000	Local materials	District DWD NARO MAAIF	Average (high ET losses)
Valley tank	Watering animals, domestic	Mbarara, Luwero	Water Time Health	Good/ Fair	Average $20,000 -100,000	Local materials		
Pots, jars	Domestic	Masaka, Mbarara	Water Time Health	Good	Cheap $85 - 160	Local materials Town	Group NGO DWD Individual	High (low evaporation losses)
Corrugated galvanized/plastic tanks	Domestic, backyard irrigation	Bushenyi, Masaka, Mbarara	Water Time Health	Good	Fair Up to $3,000	Kampala Town	District DWD	High(low evaporation losses)
Ferro cement tanks	Domestic, backyard irrigation	Mbarara, Masaka	Water Time Health	Good	Fair $300-1,000	Local materials Town	Group Mason NGO DWD Individual	High(low evaporation losses)
Brick masonry tanks	Domestic, backyard irrigation	Mbarara, Masaka	Water Time Health	Good	Fair $300-1,200	Local materials Town		
Subsurface masonry tanks	Domestic, backyard irrigation	Mbarara, Masaka	Water Time Health	Good	Fair $300-1,700	Local materials Town	Group Mason NGO DWD	High(low evaporation losses)
Rock catchment	Domestic Backyard irrigation	Luwero	Water Time Health	Good	Average up to $10,000	Local materials Town	District DWD	High(low evaporation losses)
In-situ, internal and external storage for agriculture	Agriculture, environment	Luwero, Mbarara, Bushenyi, Masaka	Yield increase Soil conservation	Good	Cheap Farm labour	Local	District MAAIF NARO	Low (evaporation and seepage losses)

It is important that water harvesting collection systems form part of an overall management plan for the homestead or groups of homesteads to conserve moisture in situ. Any measures proposed need to include other conservation activities such as eyebrow terraces and contour farming within the catchment so that the limited amounts of water falling on the catchment

[120] Typical costs for such systems are ETB 2 to ETB 3 /m^2 of cultivated area.

can be used effectively. Trees should be planted along the line of any harvesting channels to take advantage of the higher water content in these areas and also to stabilise the channels. If a communal approach to RWH is applied, it will benefit the poorer members of the community less than the well off. This is on the assumption that the systems are based on tin roofs and that these members will take over control and use of the stored water. If the CARE type rock water harvesting system is used, then this is partly overcome and if the PRA techniques that have been well developed by GOE, NGOS and international organizations are properly followed, this will not be the case.

Half the value but not necessarily the full cost of domestic water is associated with its high quality fraction that can be used for providing drinking water/cooking alone and in situations where cheap but poorer-quality sources are available for other uses. The key in the development of household water harvesting is the way in which the water is managed by the beneficiaries themselves, and the varying priorities that they attach to different sources. The weakness is the inability to provide water in the driest months of the year during periods of extended drought. Variable tank management where the amount withdrawn varies in proportion to the amount still remaining in store is a simple and effective utilisation of the stored water and has been already been practiced by some beneficiaries.

Abstraction of water from below-ground storage tanks presents problems for communities. Treadle pumps provide an appropriate low costs means of raising water to small storage containers supplying gravity drip systems[121]. Although these pumps are relatively cheap, for poor farmers they are initially not affordable as they represent the same levels of investment and the RWH tank. However, once they have started to produce backyard crops, they invest in backyard drip irrigation kits and treadle pumps. The drip kits are locally made in some of the Nile Basin countries with organisations such as the Kenya Agricultural Research Institute (KARI) carrying out research on the equipment available and providing advice and links with suitable manufacturers.

4.6 Small Scale Storage dams

Over the last three decades, many small dams have been built throughout the Nile Basin by different organizations for a variety of uses[122]. The majority were constructed to provide water storage for livestock and humans for the benefit of the communities residing near the dams. Construction was undertaken by Government Departments (i.e. Agriculture; Veterinary; etc.) as well as NGOs and Private individuals or companies and was achieved using earth moving machinery, animal drawn implements and in a few cases manual labour. Soil conservation was an important feature of these dams that included measures to protect both the catchment as well as the fringes of the reservoirs. Since the dams were built, deforestation within the draining catchments and damage to embankments and spillways by cattle and people cultivating downstream from the dams has increased the risk of dam failure. Responsibility for the well being of the older small dams in many cases is not clear and results from limited past community involvement. In most Nile Basin countries, government policy dictates that small dams are the responsibilities of the communities who should develop strategies for the repair and maintenance. However, the technical advice and support on dam design and rehabilitation needed by local communities to achieve this is in most cases lacking.

An earth fill dam can provide a cost-effective method of storing larger volumes of water for livestock or irrigation. Compared to a dugout hole where all water is stored in the excavation itself, construction costs for a dam can be much lower per cubic metre of water stored, as water is stored both behind the dam as well as in the excavated portion of the reservoir where

[121] In Kenya and other Sub Saharan countries, the charity Kickstart International has provided a good product and a network of agents who can support it with spare parts in most rural areas. (http://www.kickstart.org/)
[122] These are often called valley dams or valley tanks in some of the Riparian countries.

earth fill is obtained for its construction. Care has to be exercised when building a dam to ensure that a suitable minimum depth of water is achieved to reduce evaporation losses (d >1.0 metres) and that poorer water quality is avoided. Successful dams require the involvement of professionally qualified Engineers/technicians to undertake the planning, proper site assessment, design, construction, and oversee maintenance. Without this attention to detail, dams are in danger of washing out. Dam construction is not a "do-it-yourself" type of project.

Simple earth dams can be built where there is an impervious foundation, such as unfissured rock, or clay subsoil. The channel upstream should preferably have a gentle slope to give a large reservoir for a given height of dam. An ideal dam site is where the valley narrows, to reduce the width of the dam. National and local regulations on small dams must be checked and followed in design, construction, and maintenance. In a number of countries, suitable manuals and guidelines for smaller dams do not exist. There are a number of useful references to assist with this[123]. Safety and risk relates to dam height and a useful classification is that used for South African Dams given in Table 5.13.

Table 5.13 **Size Classification of South African Dams**

Size	Height
Small	More than 5 m, but less than 12 m
Medium	More than 12 m, but less than 30 m
Large	More than 30 m

Two main criteria are used to judge the adequacy of dam spillways in terms of flood peaks. These are the Recommended Design Discharge (RDD) and the Safety Evaluation Discharge (SED), which are defined in terms of either the return period (T) of the flood, or the Regional Maximum Flood (RMF) based on the maximum floods recorded across a region (Kovacs, 1988). The spillway must accommodate the RDD without damage, and must pass the SED without failure of the dam, although in the latter case substantial damage may be suffered by the spillway. Recommendations for different dam categories are presented in Table 5.14.

Table 5.14 **RDD and SED Values for South African Dams**

Dam category	RDD value	SED value*
I	$0.5Q_{50}$ to Q_{50}	RMF - □
II	Q_{100}	RMF - □ to RMF
III	Q_{200}	RMF to RMF + □

* RMF - □ and RMF + □ represent RMF values from the region one step lower and one step higher than that in which the catchment of interest lies, respectively

A technically competent person (engineer or technician) should be responsible for designing and supervising the construction of the dam using experienced contractors. The level of expertise required will depend on the potential for failure. Particular technical attention should be paid to the selection of materials and the design of the filter and spillway. The sizing of the spillway is important for protecting the dam during floods, but it is difficult to design. It depends on the rainfall intensity and the size and characteristics of the catchment area, and technical advice should be sought on local standards and practice. A spillway is required to protect the dam from overtopping, for example during high flows. It passes

[123] (i) Anderson, I.M., Guidelines for Design & Rehabilitation of Small Earth Dams, Danida, March 2000.; (ii) Anderson, I.M., Hydrological Design Guidelines for Small Earth Dams in Malawi, May 1998.; (iii) Fowler, J.P., The design & construction of small earth dams, IT Publications, London, 1989. (iv) Nelson, K.D., Design & Construction of Small Earth Dams, Inkata, Melbourne, 1985. (v) Pickford, J. (ed.), The Worth of Water: Technical Briefs on health, water and sanitation, IT Publications, London, 1991. (vi) Schwab, G.O., Fangmeier, D.D., Elliot, W.J. and Frevert, R.K., Soil & Water Conservation Engineering, Wiley, London, 1993. (vii) Stephens, T., Handbook on Small Earth Dams & Weirs, Cranfield Press, Bedford, 1991.

surplus water downstream safely, preventing both the failure of the dam, and damage downstream. Surplus water flows over a spillway crest at the top water level, and into an open channel around the side of the dam, discharging safely into the stream below the dam. It may be made from reinforced concrete, but a cheaper solution is a grassed spillway with a vegetated earth channel, protected crest at reservoir top-water level and a maximum velocity 2.5m/s. A grassed spillway requires regular inspection and maintenance so that erosion can be repaired and a good grass cover is maintained. It is often used together with a trickle-pipe spillway so that small inflows into a full reservoir discharge through the trickle pipe and do not erode the grass spillway.

A system needs to be established for checking of dam and spillway condition, and for arranging any necessary repair work. This will usually involve training a local caretaker, who has access to a technician who inspects the dam at an appropriate interval (e.g. before each rainy season). The dam should be regularly inspected for signs of deterioration, such as cracks, gullies, damage by rodents or insects, seepage, and damage to structures, especially the spillway.

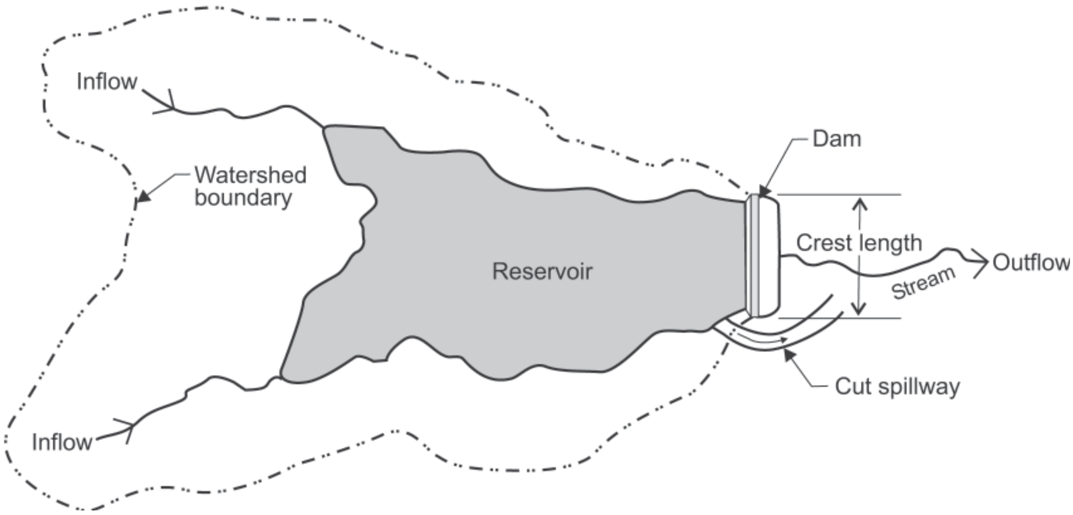


Figure 5.2 **Typical Plan of Small Dam and Reservoir**

There is a need to learn from the experiences with small dams and reservoirs within the Nile Basin countries and how they are adapting to changing runoff characteristics in the catchments and also with sedimentation and change of O&M organisation. It is essential that competent engineers are involved in the overall planning and design and that catchment management is also included as part of the implementation process (see section 4.10 below).

4.7 Sub surface dams

For thousands of years, people have survived through dry seasons by scooping water-holes in sand-rivers in ecological zones ranging from semi-arid to desert. Even today, many rural people use water-holes in sand-rivers as their only water source for domestic use, watering livestock and small-scale irrigation. Some sand-rivers provide water throughout all the years due to the favourable features of:

- The floor under the sand in a riverbed forms an upwards dyke that traps water upstream of it. An underground reservoir is thereby created from where water can be drawn.

- Coarse sand and gravel in sand-rivers can trap and store 50 per cent of water in the voids between the solids of sand. Up to 35% of this water can be extracted or in other words, 350 litres of water can be extracted from every cubic metre of sand.

The reasons for sand-rivers yielding water for only a short period after flooding, are usually the lack of underground dykes to prevent gravity pulling water downstream in a sand-river - the water-holes will therefore dry up a few weeks after flooding – or river beds beneath the sand that may have seepage lines along boulders and fractured rocks that drain water into the deep aquifer. Other factors include the volume of sand in a reservoir being insufficient to store water or the voids between the solids of fine sand being too small so that only a little water can be extracted from them. A number of approaches have been used to replicate and expand upon the traditional uses of these rivers. These include the construction of a subsurface of soil or a dam of stone-masonry that will stop water seeping downstream, thereby creating a larger reservoir, provided that both riverbanks are of sufficient height. Sand dams increase the volume of sand and water by forcing flash-floods to deposit coarse sand[124].

4.8 Spate Irrigation

Spate irrigation is an ancient form of water management for agricultural production that involves the diversion of infrequent and often extremely large flood flows, deriving from mountainous catchments in arid climates. Traditionally simple deflectors or bunds are built using local materials in normally dry river beds. Where larger flows are involved, splitters are built to divide large flood flows into smaller flows that can then be diverted on to agricultural lands. Conventional design approaches have to be considerably modified to take advantage of spate irrigation as flood flows are often of short duration, lasting in many cases for only a few hours, with high peak flows and significant amounts of suspended material. Canal systems thus have to be oversized to allow sufficient water to enter the distribution network and at the same time any structures provided must not permit the accumulation of suspended material around the structures or in the canals due to back up at the structures.

Crops grown under spate irrigation tend to be more deep-rooted crops that are also drought resistant such as sorghum. This type of agriculture is very risk prone with the crops grown utilising only a few large irrigations with the remaining moisture being made up from residual moisture stored in deep alluvial soils formed from the sediments deposited from previous irrigations over many years. In the spate irrigation areas, traditional management systems are often quite complex and extremely efficient as without this high level of co-operation, it would not be possible to manage the few peak flows of short duration. Spate irrigation is generally a subsistence activity that farmers combine with livestock agriculture to both complement it and also to utilise the crop residues produced. These livestock pastoralist activities are usually related to other areas away from the spate irrigated areas involving seasonal migration and linked to areas that have more secure water supplies for the animals during the drier parts of the year. Spate irrigation generally has low returns, generating highly variable incomes between good and bad years, and requiring very high inputs of labour to maintain intakes, canals and field systems. Where more reliable and rewarding livelihood opportunities are available, periods of drought have forced farmers to abandon their schemes and local management structures have been undermined, causing spate irrigation systems to decline and disappear.

Substantial local wisdom has been developed in the location and designing of traditional diversion weirs and intakes. Such knowledge in organising water distribution and managing

[124] Nissen-Petersen, E., Hodder and Stoughton, 1982, Rain Catchment and Water Supply In Rural Africa. UK; Nilsson, A., 1988, Groundwater Dams for Small-Scale Water Supply. IT. UK; Nissen-Petersen, E., And Lee, M., 1990, Sub-Surface and Sand-Storaqe Dams. Danida, Kenya; Nissen-Petersen, E., 1997, Groundwater Dams in Sand-Rivers. UNCHS/UNDP Burma; Erik Nissen-Petersen, ASAL Consultants Ltd, Nairobi, Kenya.

flood flows must be utilised when Spate irrigation schemes are upgraded and modernised with more formal structures being built. Depending on the location within the Nile Basin, spate irrigation schemes can cover relatively small areas of 50 to 200 ha such as in Ethiopia or Tanzania, or they can run into thousand hectares such as in the River Gash Systems in eastern Sudan[125]. Water harvesting using spate irrigation techniques is often related to storing water in dams. This is a very difficult alternative to manage due to the very high sediment loads transported by Spate Rivers resulting in short lifetimes for the reservoirs. In areas such as North West Tanzania, successes have been achieved with the improvement of the traditional Charco dams. This has been possible due to the nature of the catchment areas and the ability to exclude certain fractions of the sediment transported.

Improving traditional spate irrigation systems is complex due to the hydraulic and social aspects of the systems[126]. Limited guidance is available to those developing such irrigation systems with much relying upon the institutional knowledge of experienced engineers, agriculturalists and sociologists. The track record of improvement and modernisation of traditional spate irrigation systems has been quite patchy. Many engineers who become involved in spate irrigation prefer nicely shaped canals with clearly defined side slopes and sections, as is the case with perennial irrigation systems. By contrast the most successful systems are those that are developed on the basis of the traditional ideas using bulldozers for example to construct diversion bunds and canals and to annually remove deposited sediment from them[127].

Operation and maintenance of improved systems has to be carefully planned and thought out with limited involvement of government organisations. The communities benefiting from the system must be encouraged to develop their own mechanisms for dealing with annual O&M with governments perhaps only becoming involved when emergency repairs are required. Effective partnership with the farming communities is essential so that when the systems are designed, the scope of works reflects the farmer's wishes much more clearly than has been the case in the past. Investment costs in many of the works are very high and cannot often be justified in purely economic terms considering only the irrigation system area and benefiting farmers. The wider perspective of supporting subsistence farmers in years when the system has failed or in years of continually lower yield resulting from decline of the system must be an important overall consideration. The development of the structures within the distribution systems must be carefully considered so that they are located at points where farmers traditionally divided the water and that they do not create situations of inequality in de facto water rights or overturning of traditional long-term water rights of farmers.

4.9 Small-Scale/Community Irrigation Schemes and of Best Practice

The concept of best practice in small-scale community irrigation schemes is often more difficult to define than in water harvesting. Best practices on an irrigation scheme will often not cover the whole scheme but relate to certain key issues such as management and viability. Productivity of water use is often not included as in most cases farmers do not pay for water and have limited means of measuring it. Other factors such as the inappropriate/poor design of the system or external factors such as markets may preclude even the best efforts on a scheme to make it work.

[125] The annual irrigated area for the annual rotation is about 30,000 ha.

[126] P Lawrence, P., van Steenbergen, Dr F., Improving Community Spate Irrigation, Report OD 154, Meta Meta. February 2005.

[127] The need to utilise past experience to provide detailed guidelines on Spate Irrigation for professionals, planners and designers has been recognised and FAO and IPTRID are preparing a suitable publication (expected mid 2008) to mainstream Spate Irrigation in the training of Engineers and others involved in water development.

An assessment of the information available on small-scale and community irrigation schemes within the Nile Basin has shown that Best Practices within the schemes depends heavily on beneficiary involvement and cohesiveness of water users' organisation. If the system has been designed by the communities themselves with a minimum outside input (informal system) then this will assist in the system operation and maintenance and give a good indication of best practices. However, as has been seen in some schemes within Ethiopia, Kenya and Tanzania, if parts of these traditional systems are improved and upgraded without the full support and involvement of the community, then this will tend to work against the good operation and productivity of the system. Both in the informal and the formal irrigation systems it is most important that structures are located in places where farmers want them, and that the operation and maintenance of the water supply system through these structures is geared to the capacity and the ability of the farmers and their organisation.

In most cases, examples of best practice appear on those simple gravity irrigation systems that are operated and maintained within the limited resources of the communities depending upon them. Information on Tanzania has shown the vulnerability of these communities to vagaries in the rainfall[128] and thus it is important that the irrigation scheme can meet their needs and provide them with a sufficient basic income both in wet and drought years. The studies on best practices carried out by the National Consultants in November and December 2007, showed that there is in adequate information and details on the existing small-scale and community irrigation within the Nile basin countries. Tanzania has a good inventory of the irrigation systems that was completed under the Irrigation Master Plan, but there are still many schemes for which adequate data are not yet available. When assessing the level of success of an irrigation and drainage scheme, key descriptors (Table 5.15) provide a good overview of the aspects which could be considered. These factors have been prepared considering benchmarking of irrigation and drainage projects to identify areas for improvement as well as comparison between different projects.

[128] Hatibu and Mahoo (2000). Noted that 98% of crop production in Tanzania is rain-fed; Drought occurs once in every 4 years, affecting mostly the central regions of Dodoma, Singida and Tabora, Shinyanga, Mwanza and Mara; RWH/SSI are particularly necessary as 71% of all disasters are caused by droughts (33%) & floods (38%).

Table 5.15 Key descriptors for irrigation and drainage schemes

Descriptor	Possible options	Explanatory notes	Example
Irrigable area	-	Defines whether the scheme is large, medium or small scale	8567 ha
Annual irrigated area	Area supplied from surface water Area supplied from groundwater	Shows the intensity of land use and balance between surface or groundwater irrigation	7267 ha 4253 ha surface 3014 ha groundwater
Climate	Arid; semi-arid; humid tropics; Mediterranean	Sets the climatic context. Influences the types of crops that can be grown	Mediterranean
Average annual rainfall (P)	-	Associated with climate, sets the climatic context and need for irrigation and/or drainage	440 mm
Average annual reference crop evapotranspiration (ET_o)	-	Associated with climate, sets the climatic context and need for irrigation.	780 mm
Water source	Storage on river; groundwater; run-of-the river; conjunctive use of surface and groundwater.	Describes the availability and reliability of irrigation water supply	Over-year storage reservoir in upper reaches. Ground- water aquifers.
Method of water abstraction	Pumped; gravity; artesian	Influences the pattern of supply and cost of irrigation water.	Gravity fed from rivers, pumped from groundwater
Water delivery infrastructure	Open channel; pipelines; lined; unlined	Influences the potential level of performance.	Open channel, lined primary and secondary canals
Type of water distribution	Demand; arranged on-demand; arranged; supply orientated	Influences the potential level of performance.	Arranged on-demand
Predominant on-farm irrigation practice	Surface: furrow, level basin, border, flood, ridge-in-basin; Overhead: rain-gun, lateral move, centre pivot; drip/trickle Sub-surface: drip	Influences the potential level of performance.	Predominantly furrow, with some sprinkler and (increasingly) drip
Major crops (with percentages of total irrigated area)	-	Sets the agricultural context. Separates out rice and non-rice schemes, monoculture from mixed cropping schemes.	Cotton (53%) Grapes (27%) Maize (17%) Other crops (3%)
Average farm size	-	Important for comparison between schemes, whether they are large estates or smallholder schemes	0.5-5 ha (20%) >5 – 20 ha (40%) >20 – 50 ha (20%) > 50 ha (20%)
Type of management	Government agency; private company; joint government agency/farmer; farmer-managed	Influences the potential level of performance.	River system – Government; Primary and secondary systems – Water users associations.

Source: Bos, M.G., Burton, M.A., Molden, D.J., Irrigation and Drainage Performance Assessment, Practical Guidelines, CABI, 2005.

Crop yields vary considerably with management practice, the natural soil fertility, the genetic production potential of seeds, and the efficiency of extension services. Crop failures due to shortage or poor distribution of rainfall can be excluded in irrigation agriculture. Irrigated crops will provide substantially higher yields with improved crop management and crop intensity can be increased considerably through irrigation. It is perceived as a well-managed crop under indigenous management with low external inputs of fertilizer and mainly local seed varieties. Appropriate agricultural extension is required to realise the calculated production level.

Improved management requires intensive agricultural extension support and provision of improved inputs, currently not available in many irrigation schemes. However, in many cases yields on SSI or CMI do not present maximum production levels comparable with commercial schemes. Producer prices show significant seasonal and regional differences. Seasonal producer prices are usually lowest shortly after harvest but depend also on regional pre-harvest yield assessments. Some crops, such as onion can achieve very high prices shortly before religious and cultural festivities in Ethiopia for example.

Over the last decade an increase in traditionally irrigated areas has been observed due to the growing pressure to intensify agricultural production, high population growth and shortage of arable land. However, traditional irrigation has not been supported by agricultural extension that has targeted rainfed crop production. Input and production levels have therefore largely remained at a low level. In terms of total area and significance, traditional irrigation still outranks modern irrigation schemes in most regions of Ethiopia[129]. With the growing need to intensify farming systems in food insecure Districts, traditionally irrigated areas hold a significant potential to increase agricultural production and improve local food security.

4.10 Best Practices Studies

A second series of reports by National Consultants was undertaken to examine best practices (BP) of water harvesting, community irrigation and public-private irrigation within each riparian country. The aim was to identify BP sites that can be utilised for obtaining more detail on the ways in which activities should be approached to achieve sustainable and beneficial interventions. These sites will be examined further to provide key information on water use efficiency (measured in terms of production per cubic metre of water diverted; ratio of water diverted to water utilised; water applied at field in relation to consumptive years). Other details collected include (a) how the systems are managed; (b) to what (physical) level the community manages a system; (c) at what level should the public sector be involved in MOM (for main and secondary canal only for example); (d) how the communities are organised (informal/formal WUAs; management committees;); (e) whether such users groups are effective; (f) what legislation governs/enables the WUAs and the suitability.

All studies collected data from each Nile Basin country and the results were compiled in identical formats to facilitate comparison between each. The reasons for selection of particular sites were clearly set out together with the conditions under which it can be replicated and spread more widely. The Consultants were asked to try and select sites throughout their country, on the proviso that there could be good examples with applications both within the country and the Nile Basin as a whole. The agro-ecological zone[130] within which each BP scheme or site (or group of sites) is located was identified to capture (to the extent possible) the range of variation that may exist in a given region.

4.11 Workshop on Best Practices

Prior to completion of the BP National reports, it was considered important that EWUAP working group representatives and national project coordinators from the member countries had an opportunity to discuss the subject of best practices, define what is meant in each country, be introduced to the first ideas of the consultants, both national and International, and discuss the Best Practice sites already identified. All countries were represented at the Inception Workshop[131] and presentations from seven countries were discussed. Participants have the opportunity to review the approach and findings on an informal basis and to discuss issues arising, to reach a consensus on the consultants' findings and to identify issues that they need to take into consideration when producing and finalising their reports.

[129] Traditionally irrigated area in Amhara Region was estimated at 65,000 ha in 2002 with modern irrigation schemes irrigating 9,700 ha. In Oromia Region, traditional irrigation was estimated at 54,800 ha versus 51,330 ha for modern schemes.
[130] To support this it is important that an AEZ map is included for the country and that the definitions of the zones are also included.
[131] Held in Nairobi from the 27th to 28th November 2007, was attended by 33 participants as well as staff from EWUAP - see Proceedings of Inception Workshop-(V5).doc

The overall objective of the workshop was to agree on the approach towards Best Practices and what they comprise, and to confirm selected Best Practice Sites for Water Harvesting (WH) Community Managed Irrigation (CMI), and Public-Private Managed Irrigation (PPMI). Understanding of best practice varies between the NB countries and depending upon the viewpoint adopted (Designer; Manager; Operator; Water User Association; Manager). Although it is not expected that perfect examples of best practice will be identified, it was important to establish the reasons for identifying them and how they would be utilised. Best Practice (BP) must cover the practices actually in use and not just ideas being examined on Research Stations. Africa has many research ideas, but a large gap exists between research and what the farmers need and are using.

4.12 Overview of Findings on Best Practices in the Nile Basin

The current impacts of climate change have renewed interest in water harvesting in Africa. Over the last two decades, the need for rainwater harvesting has been growing not only for crop production, but also for livestock and household use. About 69% of land in eastern and southern Africa falls within arid, semi arid, and dry areas where permanent rivers are few and far between. Groundwater exploration, development and abstraction in most cases is beyond the reach of farmers and not readily available. The growing interest in alternative sources of water that are both affordable and could be implemented using local resources and knowledge has led to resurgence in activities in this sector. Throughout the Nile Basin, good examples of water harvesting can be found. In many cases the interventions derive from the non-government sector although support is provided by government officers and extension services. Some of the greatest impacts have been achieved under the programme initiated by RELMA in the 1980s that linked with national water harvesting associations and assisted in training and implementation to ensure that they became well established. A wide range of technologies and approaches are available, but governments are still not committed to support the interventions that will have sustainable and widespread impacts.

In the northern parts of the Nile Basin in Sudan and Egypt, the emphasis has been more on spate irrigation and storage dams. In eastern Sudan in Kassala province, spate irrigation has been carried out for many years and successful approaches have been developed. Sedimentation is still a major issue and increasing due to the impacts of population pressure and deforestation in upper Nile catchments. Livestock is an important part of the farming system in many arid and semi arid areas of the riparian countries and watering of livestock is vital in ensuring the livelihoods of the pastoralists, the well-being of the animals and that environmental degradation is not exacerbated by overgrazing. Although this has been successfully addressed using water harvesting in a number of countries such as Uganda with its valley tanks, much more work is needed within the Nile Basin countries to ensure wider and sustained use of such water harvesting techniques. The most important factor is ownership by the communities who will be utilising the water collected and their adoption of responsibility for O&M. Experiences in Sudan has been varied with many of the interventions failing as nomadic herdsman fail to accept maintenance responsibility for these often remotely located facilities.

In the other countries of the Nile Basin, a full range of water harvesting techniques has been developed. In many cases water harvesting interventions are seen in isolation from the full range of techniques that are available and in particular for the need to integrate these with other activities in a particular watershed. Over the last 10 years in Ethiopia, successful interventions supported by the world food programme (WFP) have concentrated on the importance of linking all activities within a particular sub catchment. Such approaches take time to produce results and it is fortunate that the donor support to these it activities survived both changes in government and changes in staff. The lessons learnt relate to implementation at the appropriate village level aimed at natural resource management with a long term prospective. Although guidelines have been provided by RELMA to the local water harvesting associations, changes in institutional arrangements, periods of insecurity within the countries and varying priorities have resulted in inadequate manuals being available to field staff for the implementation of appropriate techniques. All Nile Basin governments need to review the roles and responsibilities for water harvesting, providing support to the field staff that will implement and support the communities and equipping them with appropriate training and guidelines to enable them to implement the water harvesting techniques in an appropriate and sustainable way.

Water Harvesting cannot be treated in Isolation: Considerable experience on RWH is already available within the Nile Basin and, where facilities have been provided, the impact is very marked. However, cross communication between different organizations and government departments has been poor and constrained the more rapid acceptance and uptake of techniques and approaches. Water harvesting for any particular use cannot be treated in isolation but must be linked with the livelihood and farming systems of the communities. In the rural areas, people live in larger formal villages, small communities or in groups of houses. They work together and respect the needs of others and this must be built upon when planning water harvesting interventions and programmes.

Adapted to Beneficiary Priorities: Whether the objective of RWH intervention is to provide water for drinking or crop production: if the former is lacking, any storage of water provided at or near the homestead will be used for household and animals. Farmers have their own priorities and the sources that they consider best and most suitable for different uses (whether it is for drinking, household use or the supply of newly born animals and small ruminants). Any interventions must work with the rural communities to examine their water needs, priorities and their own labour resources. Reduced workloads involved in collection of water enable labour to be diverted to productive uses and income generating activities. How harvested water will stored at the homestead and used in relation to other sources and available labour is thus an important consideration.

Design and Implementation: An assessment of the organizations involved in water harvesting has shown that there are many similar approaches to design and implementation. Although much information is available and the means for interaction and exchange of ideas is available through the local Rain Water Harvesting Associations, many designers do not take advantage of existing experiences and wide ranging knowledge available. Significant work is being carried out and design manuals and guidelines available. The pooling this information on designs, approaches and resources is needed and wider dissemination will result in appropriate and improved interventions and structures.

Crop Production and tank filling regime proposals must prepared along with structural designs when completing plans for agricultural back yard production for improvement of household food security. The methodology for determining crops to be grown and crop water requirements should utilise the readily available CROPWAT programme developed by FAO[132]. It would greatly assist designers if a series of options were developed according to the agro-climatic zones.

Size of Catchment Area: Rainfall gives high variability over short distances and where reliable rainfall estimates are not available, care must be taken when designing runoff-harvesting systems using average rainfall data. Estimates of runoff are available using empirical methods that relate catchment size and cover with anticipated rainfall amounts. Realistic conservative estimates of number of rainfall days are needed with designs developed relating catchment area/yield with appropriate storage volume ratios.

Type of Storage: The advantages of buried and surface storage (Tables 5.8 & 5.9) need to be assessed on a site-by-site basis relating ease of storage with water sources and quality.

[132] Available for download from the FAO website: http://www.fao.org/ag/AGL/AGLW/cropwat.stm

Cleaning and regular maintenance by rural communities, even though they have received substantial training and assistance, will always be less than anticipated. Above ground storage for drinking water enables visual inspection checks to identify possible leaks and structural problems. For storage for agricultural back yard crop production, covered below ground tanks with steel sheeting supported by steel trusses are much more durable and are easier to fill from surface runoff. Timber supports suffer from rotting due to the humidity created beneath the roof.

Training Support: Training in health, hygiene and the need to keep the catchment areas clean must accompany any support provided for water storage at household or group level. This has formed the thrust of work with communities by NGOs who all seem equipped to use PRA techniques to involve the communities to develop committees to construct, operate and manage the facilities when built.

4.12.1 Prioritization and Selection processes and Results

The National consultants, who examined the best practices in the riparian countries during November and December 2007, each prepared a system for ranking their projects using guidelines prepared by EWUAP. Main considerations for ranking of water harvesting projects (Table 5.16) and small-scale community irrigation and public-private partnerships (Table 5.17) can be used widely as these identify the issues that all planners and designers should be using. It can be seen that community involvement and adoption by them rates highly for all systems including RWH. This derives from past experience whereby many schemes have failed or have been unsuccessful due to a lack of sufficient involvement of the communities in the early stages of project preparation/rehabilitation and subsequent O&M.

The selection of the best practices and sites was accomplished using the ranking system and the results were confirmed through field visits and discussions with those familiar with the projects. National Project Coordinators and experienced professionals in both the public and private sector provided the necessary peer reviews and comments. Some sites did not fulfil all the criteria for best sites but have outstanding attributes above other practices/sites in the country. During Phase 2 of this project, further work will be carried out to ensure that the sites are replicable, practical and do in fact represent Best Practice on the ground.

4.12.2 Country-Specific Results

Country scale studies made to identify more clearly areas having good RWH and CMI potential. Although these were examined during the inception workshop, it was felt that had the Consultants had more time a wider range of sites could have been examined. However, a start was made on the process and with the help of the National project Coordinators and additional work during Phase 2, it is anticipated that more information and sites would be identified. At the start of the Phase 2 process, validation workshops will be held to discuss these country specific best practices and other issues. This will enable the essential outcomes to be achieved that are: (a) Agreement on National Best Practice Reports; (b) Agreement of sites selected for Best practices; (c) Completion of List of Institutions in Country for supporting Best Practice; (d) Validation of Report by the Workshop; (e) Recommendations for follow up/action including other strong contenders for Best Practice sites.

Examples of all of the Best practices discussed earlier in the Chapter are found in the Nile Basin, but more work is needed during Phase 2 to confirm how these sites could be used and upscaled throughout the Nile Basin and relate these to Agro-Ecological zones. In the following section, resulting Best practices that are considered to be of basin wide relevance are listed with observations for member countries. A compiled summary of best practices at basin level based on the preliminary lists of the National Consultants is also provided.

Burundi. The period of turmoil in the country has meant that information on both with rainwater harvesting and irrigation systems is not sufficiently detailed or comprehensive enough to identify the full range of best practices that may exist. It was clear that there are good examples of in situ water harvesting, use of stored water for both drinking and also for agricultural production and that there were good examples of effective water users associations. The strength of these associations is illustrated by the fact that they still exist even though the turmoil has put considerable pressure on the social fabric. More work will have to be carried out in this area to identify sites that have wider application and which can be utilised by the country to illustrate techniques to other potential users. There is currently no list of BP Sites in Burundi.

Egypt. The best practice sites (Table 5.19) for water harvesting involve a range of techniques for improving rainfall infiltration, prevention of flash flooding utilisation of ground water and the reuse of drainage water. Some of these have wider application in other arid parts of the Nile Basin, such as Sudan, but will need some adaptation before they can be used in the upper parts of the Nile Basin. For irrigation, the identification of best practice relates to the management of water within the existing large irrigation schemes. Under the irrigation improvement project, considerable improvements have been made in reducing the amount of water delivered to each farm and hence used by farmers in the production of their crops. With the introduction of upstream water control and shared water pump stations as opposed to individual stations, not only has water usage per hectare been reduced, but also the production costs for all crops has been lowered. Farmers have a better understanding of water management through involvement of their water users associations at quaternary and tertiary level. This provides a good example for similar larger scale systems elsewhere.

Ethiopia is a heterogeneous country with sharp gradients in rainfall, topography, population density, land uses and soils. Sites for RWH and SSI therefore vary accordingly. However, the need for RWH and improved irrigation has been expressed throughout the whole country although within the Nile basin there have been less developments than elsewhere in the country. It is not easy to delineate priority areas but the results showed that integrated watershed management had produced the most comprehensive results (Table 5.20). The success of community managed irrigation schemes centres around the organisation of the Water Users Association and the proximity to markets. Those schemes with effective WUA management have been able to realise significant benefits for their members. The public private managed irrigation schemes relate to larger scale schemes within the country growing sugar or flowers for the export market. Although there are some 66 farms aimed at the export market, most are in the private sector and information is difficult to obtain to identify best practices. The fact that they are still in business and have a positive balance sheet would indicate that best practices exist with principles that could be applied elsewhere.

Table 5.16 Ranking of WH practices - All Countries

Community	Technical Solution	O&M:	Cost/Economics	Sustainability
Community participation	Level of solution to problem	Operation and maintenance simplicity	Cost /Initial Cost	Sustainability (recent to > 8 yrs)
Sustainability: (recently introduced to indigenous)	Technical implementation (simple to complex)	O&M - arrangements	Cost effective	Replicability
	Multiple use of harvested water	Effective O&M System	Economic benefits	Area coverage compared to the potential
Organized community leadership/WUA	Technical skills required	Spare parts availability	Benefit/Cost Ratio	
Socio-cultural acceptability	Suitability (Topography; Land Use; Water availability; etc)		Delivered Proven Successful Results (Multiple Benefits)	Socioeconomic (Diversity) importance of the irrigated crops
Population benefiting	Complexity in construction/implementation			
	Labour requirement		Affordability	Adoption rate (No of community members that adopt technology)
Well Adopted and Owned by the Local community	Efficiency (water use, application)		Accessibility to markets	
	Multiple use of harvested water : Irrigation; domestic water supply; livestock water supply; SWC; GW recharge; apiculture			

Potential for out scaling	Support Services	Institutional	Environmental impacts	
Potential for out scaling	Technical support	Acceptability by government and other institutions	Notable +ve environmental impact	
Range of climatic conditions	Vicinity to support institutions	Upstream-downstream committees	Environment Friendly	
Diversity of WH practices	Capacity building of community	Government support in policy and finance		

Table 5.17 Ranking of CMI, SSI and PPMI practices - All Countries

Community	Technical Solution	O&M:	Cost/Economics	Sustainability
Community participation	Level of solution to problem	Organization set-up	Cost /Initial Cost	Sustainability (recent to > 8 yrs)
Sustainability: (recently introduced to indigenous)	Existing irrigated area/potential area	Decentralization of decision making	Cost effective	Replicability
Social factors	Technical implementation (simple to complex)	Operation and maintenance arrangements & simplicity	Economic & Financial benefits & Viability (Benefit/Cost Ratio or EIRR)	Efficiency (water use, application)
Organized community leadership/WUA	Water abstraction method	Effective O&M System	Yield increase/profits %	Socioeconomic (Diversity) importance of the irrigated crops
Socio-cultural acceptability	Sustainability of water sources (Durability, Quantity and Quality)	Establishment of O & M committee	Water use efficiency	Adoption rate (No of community members that adopt technology)
Population benefiting	Suitability (Topography; Land Use; Water availability; etc)	Status of operation/Maintenance of the scheme	Affordability	Food security assurance in scheme villages
Socio-cultural acceptability	Protection against drainage & flooding problems	Training for O & M	Accessibility to markets	Physical improvement of the delivery system
Well Adopted and Owned by the Local community	Technical skills required by implementers	Spare parts availability	Improve socio-economic return and marketing	Implementation of Integrated Water/Land Management
Farmers participation (WUAs), and Institutional reform	Complexity in construction/implementation	Lining of irrigation canals	Accessibility to site	Improve farmer health conditions and general awareness
	Efficiency (water use, application)		Delivered Proven Successful Results (Multiple Benefits)	
Potential for out scaling	**Support Services**	**Institutional**	**Environmental impacts**	
Potential for out scaling	Technical support	Acceptability by government and other institutions	Notable +ve environmental impact	
Range of climatic conditions	Vicinity to support institutions	Upstream-downstream committees	Environment Friendly	
Area coverage compared to the potential	Capacity building of community	Government support in policy and finance	Water-borne diseases	
Technical skills required	Improved agronomic practices	Capacity building of community	Water quality	
			Sedimentation	
			Salinity and Alkalinity of soils	

Table 5.19 Identified BP Sites in Egypt

EGYPT			
Water Harvesting Sites			
Site	**Region/District**	**Type**	**Use**
Um Ashtan-Matrouh	Matrouh; North West Coast	Spring Development; Rock and other surface catchment systems; Recharge Structures; Crescent shaped dam/ Water Ponds/Pans; Small Dam - earth embankment; Roof Water Harvesting; Runoff Water Harvesting; diversions for SSI;	Domestic; Livestock; Agricultural/Homestead; Soil & Water Conservation on arable rainfed lands.
Wadi Watiir-Sinai	Wadi Watier; Sinai	Crescent shaped dam/Water Ponds/Pans; Small Dam - earth embankment; Roof Water Harvesting; Runoff Water Harvesting; diversions for SSI;	
Siwa oasis	West Desert	Spring Development; Sub-Surface irrigation ; Surface drainage; shallow Well; Runoff Water Harvesting; diversions for SSI; Spate Irrigation; Soil conservation	Domestic; Livestock; Agricultural/Homestead; Soil & Water Conservation.
Wadi Rayan	Fayoum	Water Ponds; WH for fishing and new community; Runoff WH; Agric drainage water harvesting for SSI; Spate Irrigation; Recharge Structures; Soil & Water Conservation	
Best practice sites for PPMI/CMI			
Site	**Location/District**	**Crops/Practice**	
Bahr El-Nour	Delta Area	Control of irrigation water: main canal (automation); sub-branch (one lifting point); Strong WUAs at all levels; Good management at farm level; economically supported	
W/10- Sefsafa	Old land-Lower Egypt; CMI Large Scale	New design/operation criteria at sub-branch and tertiary canals (Meska and Merwa), by (electric pumps and improving ditches); Combination of fresh/drainage water for irrigation	
Sakha	Delta - Research Unit	Good link between users & research - supporting beneficiaries with new practices (new rice varieties; crop rotations)	
Sela District; WUA - LSI	Middle Egypt-Fayoum	Large scale WUA O&M; self-managed at all levels; good cooperation between Gov. & users; represents cropping/irrigation in Middle Egypt;	
Bani Abad	Upper Egypt-Menya	Small scale/sustainable WUA at tertiary level (operated for 15 years); self-finance organisation; represents lower part of Nile valley with different cropping patterns.	
Dina Farm	BP in New lands (Private sector)	Farming/irrigation of newly reclaimed lands; Fully controlled by private investors; serves local/outside markets; Economic/environmental aspects; integrated agricultural/animal production	

Table 5.20 Identified BP Sites in Ethiopia

ETHIOPIA			
Water Harvesting Sites			
Site; Ownership	**Region/District**	**Type**	**Use**
Abreha Atsbeha	Tigray; Kilte Awlaelo	Integrated Watershed Development	Crop/Wood Production; Conservation; Conservation;
Mekuh Integrated	Tigray; Kilte Awlaelo		
Migulat Mekodo	Tigray; Ganta Afeshum		
Gergera	Tigray; Atsbi Wemberta		
Ayub	Amhara; Kobo		
Chekorti	Amhara; Kalu		
Lenche Dima	Amhara; Gubalafto	Watershed Development	
Totit Wajeto	Amhara; Ambasel		
Golbo	Amhara; Ambasel		
Hato	Amhara; Bati		
Minjar	Amhara; Minjar	WH Storage Sites; Plastic Lined Ponds	Crop Production
Boset	Oromia; Boset	WH tanks and moisture conservation	

Community Managed (Small Scale) Irrigation Sites		
Site; Ownership	**District**	**Crops /Practice**
Mai Negus	Tigray; Laelay Maichew	Higher application efficiency, income per cropped area and output per unit water
Godino	Oromia; Adaa	Increased income & living standard of Irrigators
Chole	Oromia; Ambo	Good Irrigation management and Strong WUA
Indris	Oromia; Ambo	Good Irrigation management and Strong WUA
Taltale	Oromia; Ambo	Expansion of irrigable area
Kobo-Alewuha	Amhara; Kobo	Good Irrigation management and Strong WUA

Burka Weldiya	Oromia; Jarso	Deficit irrigation and effective traditional WUA
Best practice sites for large scale irrigation		
Site; ownership	**District**	**Crops**
Melka Werer Research Center	Afar;	Irrigation Water Management for Cotton on Vertisol
Dodicha Pumping CMI Scheme	Oromia; Ziway	Out-grower Contract with Exporter
Sugar Processing Factory at Wonji-Shewa	Oromia; Adaa	Out-grower Contract

Kenya is a relatively dry country with population concentrated around the wetter central highlands and the Rift Valley. RWH and CMI reveal the same pattern, especially for roof top and runoff harvesting. Sand dams are potentially applicable in the dry areas with in-situ RWH applicable to the central areas where accommodating land use patterns are present. Rainwater harvesting has been supported extensively over the last 10 year and more so than in any other Nile Basin country. The result has been that there are many good examples and areas where uptake has been higher than expected. Practices have been replicated elsewhere with the support of both government and owners. A full range of techniques are available and utilised and the example of Lare near Nakuru has much wider applications throughout the Nile basin (Table 5.21). Information on CMIs sites within the country are not yet available, although with the trend of government to handover management to the communities will have identified some sites with good practices.

Table 5.21 Identified BP Sites in Kenya

KENYA			
Water Harvesting Sites			
Site; Ownership	**District**	**Type**	**Use**
Lare division	Nakuru	Terracing and grass strips, runoff water harvesting from roadside drainage, roof catchment, and farm ponds	Domestic; Livestock,; Conservation; agricultural production;
Ndeiya Karai sub-location	Kiambu	N?A	N?A
Naromoru division	Laikipia	N?A	N?A
Utooni sub-location	Machakos	N?A	N?A
Mutomo division	Kitui	N?A	N?A
Community Managed (Small Scale) Irrigation Sites			
Site; Ownership	**District**	**Crops**	
Kibirigwi	Kirinyaga	French Beans	
Mitunguu	Meru central	N?A	
Alanyahoda	Nyando	N?A	
Asunda	Nyando	N?A	
Alungo	Nyando	N?A	
Abwao	Nyando	N?A	
Ngura	Homa bay	N?A	
Wahambla	Homa bay	N?A	
Best practice sites for large scale irrigation			
Site; ownership	**District**	**Crops**	
Mwea	Kirinyaga	N?A	
Perkera	Baringo district	N?A	
Bura	Tana River	N?A	
West Kano	Nyando	N?A	
Ahero	Nyando	N?A	
Lower Tana	Tana River	N?A	

Rwanda is an equatorial country with high rainfall, high population densities and steep slopes. Because of past political instability, data of best practices in the country are not as comprehensive as some other NBI countries. However, irrigation and water harvesting sites were identified and reported[133]. More details still remain to be investigated in order to provide a complete inventory. It is clear that good examples of best practise exist and that the government is committed to improving the uptake of water harvesting technologies. In spite of steep land slopes and high population densities, erosion levels are less than would be expected. For socio-economic reasons, rooftop RWH is nationally adopted with supporting laws and this is a good example for other riparian states. Sand dams may not be a priority in Rwanda but runoff harvesting is feasible, especially in the drier south western areas.

Table 5.22 Identified BP Sites in Rwanda

RWANDA			
Water Harvesting Sites			
Site; Ownership	**Region/District**	**Type**	**Use**
Rwibishorogoto	Eastern, Nyagatare	Valley dam	Livestock; Domestic
Rwimiyaga (Rwimiyaga)	Eastern, Nyagatare		
Rukindo	Eastern, Nyagatare		
Gakagati	Eastern, Nyagatare		
Kiyovu	Eastern, Gatsibo		
Kiyovu	Eastern, Gatsibo	Water pond	
Kanyonyomba	Eastern, Gatsibo	Valley dam	
Cyabayaga	Eastern, Nyagatare	Water Pond	Domestic; Crop production
Muvumba (Rukomo)	Eastern, Nyagatare	RWH	Domestic
Nasho	Eastern, Bugesera		
KISARO	Gicumbi, Northern Province	Terracing	Crop production
Kigali urban area	Kigali City	RWH	Domestic; Crop production

Community Managed (Small Scale) Irrigation Sites		
Site; Ownership	**District**	**Crops /Practice**
Biringanya	South	N?A
Munyazi (Nyanza; Rukira; Nkima; Sovu)	South, Huye	N?A
Rwasave	South, Huye, Mbazi	N?A
Rwasave	South, Gisagara, Kibirizi	N?A
Rwasave	South, Gisagara, Save,	N?A
Mukunguri	South, Ruhango	N?A

Best practice sites for large scale irrigation		
Site; ownership	**District**	**Crops**
Rugeramigozi 1 (Gahogo)	Muhanga, Rugeramigozi	N?A
Gahenerezo (Gahenerezo)	Huye, Ngoma	N?A
Rwasave 1	Huye, Ngoma	N?A
Kanyonyomba	East, Gatsibo	N?A
Gakirage	East, Nyagatare, Nyagatare	N?A
Gashora	East, Bugesera	N?A
Nasho	East, Bugesera	N?A
Codervam-Ngarama	East, Muvumba	N?A
Nyacyonga (sprinkler), Nyacyonga	Kigali, Gasabo	N?A
Kabuye	Kigali, Gasabo	N?A
Mulindi (sprinkler)	Kigali,	N?A
Nyacyonga (drip)	Kigali, Gasabo	N?A

Sudan. Data on best practices in Sudan have not yet been compiled into a best practice study due to the late identification of a national consultant. However, there are good examples of best practice for spate irrigation in the east and south west of the country and these illustrate the good levels of community organisation that enable sediment removal from the spate systems as well as the sharing of water amongst many farmers in the extended traditional systems. Lessons from these areas can be applied to similar agro ecological zones in all of the

[133] Francois-X, Dr Ir Naramabuye. December 2007.

member countries, especially relating to exclusion of sediment and implementation of operation and maintenance.

Tanzania is one country where runoff and in-situ RWH have been widely adopted and illustrates good examples of tried practices both for water harvesting and community managed irrigation systems. Various projects supported by IFAD and the World Bank have shown how incentives for wider adoption can be achieved through close involvement and empowerment of communities. The country has large areas with medium rainfall, a well distributed population and gently undulating topography suited to RWH. All types of RWH are potentially applicable to most of the country with the exception of protected areas and high altitude mountains. Makanya catchment is a highly ranked WH site (Table 5.23) with its semi-arid climate and unreliable/poorly distributed rainfall and where RWH is highly practiced with a high level of adoption in the area. More than 60% of households practice RWH for crop production and domestic water supply and 40% for livestock[134]. RWH schemes have been initiated, financed and developed by farmers, with minimal external assistance. RWH has received attention from policy makers, planners and NGOs in the District (DALDO, 2001 and SAIPRO, 2001). Lekitatu irrigation scheme was ranked the highest CMI scheme as it has a strong farmer's organization with strong committees[135]. Since 1996, farmers have been attending training[136], (from KATC, TPRI and Arumeru District Council) and this has assisted in improving agricultural production. Private-managed irrigation sites are wide spread over the country and detailed in formation is not readily available. Kibena Tea Ltd is highly ranked as it is well organized and a good example of a high level management of sprinkler and drip irrigation systems (Mkoga et.al. 2005). Irrigation managers use climate data to determine crop water requirement and planning irrigation scheduling and assess farm productivity together with other data (Kibena Tea Estate, 2003). The Kibena piped irrigation system is equipped with measuring devices that constantly monitor irrigation application uniformity, yield and most importantly the cost of pumping water. A high weighting is given to water management to justify water pumping costs and to optimise profit. As such they have incorporated in their management system a way to assess productivity of water. The scheme has a positive image in the surrounding communities with employment opportunities and contributions to the education sector through Kibena Tea Fair Trade Fund (KTFTF). Other potential PPMI sites with Best Practices exist but data are currently not available.

[134] They include: ridges, bunded fields (jalubas), charco ponds (lambos), roof top and tanks, bench terraces, fanya juu, spate irrigation, storage reservoirs (ndiva), and trash lines.
[135] called UWAMALE (Umoja wa Wamwagiaji Maji Lekitatu).
[136] The training included water management, use of simple farm machinery, cooperatives, agribusiness, marketing, rice agronomy and handling and use of agro-chemicals, including fertilizer, herbicides and pesticides.

Table 5.23 Identified BP Sites in Tanzania

TANZANIA			
Water Harvesting Sites			
Site; Ownership	**District**	**Type**	**Use**
Makanya catchment, Makanya village	Same District, Kilimanjaro Region	Spate Irrigation	Field Crops
Makanya catchment	Makanya Village- Kwesasu Subvillage	Charco Dam	
Makanya catchment	NDIVA -Champishi -Chome village	Bench Terraces	Variety of crops
Makanya catchment	NDIVA Mgungani/ Manolo	Ndiva	
Bukangilija / Njiapanda villages	Maswa district, Shinyanga region	Jaluba	
Ilonga	Kilosa		

Community Managed (Small Scale) Irrigation Sites		
Site; Ownership	**District**	**Crops**
Lekitatu - 400 ha	Usar River ward, Arumeru District, Arusha	rice; Pigeon Peas; Beans
Mwega - 640 ha	Kilosa district, Morogoro	Paddy; Maize - rainy season; Onions; Cabbage; Potatoes; Pulse
Mombo - 220 ha	Mombo town, Korogwe District, Tanga	Rice
Kikafu Chini - 327 ha	Rural Moshi District,Kilimanjaro	rice, beans, banana, and vegetables
Mkindo - 500 ha	Mkindo, Turian, Mvomero District, Morogoro	Rice
Lumuma - 980 ha	Kilosa District, Morogoro and some parts of Mpwapwa District.in Dodoma	Paddy, maize, and Beans in rainy season and onion, cabbage and tomatoes in dry season
Lower Moshi - 1,300 ha	Rural Moshi District, Kilimanjaro	Paddy and some upland crops
Dakawa - 2000 ha	Mvomero District, Morogoro	Rice Farm

Best practice sites for large scale irrigation		
Site; ownership	**District**	**Crops**
Kibena - 730 ha; Kibena Tea Ltd	Njombe District, Iringa Region	Tea
Kilombero - 8605 ha; Kilombero Sugar Company	Kilombero District, Morogoro	Sugar
Kapunga - 1200 ha; Kapunga Rice Project Ltd	Chimala, Mbarali District, Mbeya Region	Rice

Uganda combines high rainfall with high population and large areas prone to wetland conditions, yet RWH is an important source of water due to poor state of development of centralized systems. In addition, the “cattle corridor” comprising north eastern to western Uganda is a relatively dry zone where RWH is necessary even for crop production. Most of the country would benefit from roof water harvesting and about half of the country would benefit from harvesting of runoff and in-situ RWH for improved agricultural production. The best practice for roof water harvesting was found to be surface FCT (Table 5.24). It is cheaper to construct than brick, underground, plastic and corrugated iron tanks. It does not crack easily and is easy to repair and maintain by individual farmers or local masons. Local materials for construction such as sand and stones are available and cheap. The best site for CMI was found to be Mr.Sembusi Richard of Bulenge Village Buwunga Sub County. It comprises a gravity irrigation system fed by diverted river water. Water is applied to the crops by buckets. The system is used by a group of about five farmers with Mr. Sembusi being the lead farmer. The water use efficiency is low but the system is cheap, has good water control system, is profitable and is well managed. The best site for public/private managed irrigation was found to be Doho rice scheme in Buteleja (Tororo) district. Although the water use efficiency and management are poor, community participation is very high (4,385 persons) and the yield above average (3 tons/ha/season). The next best practice site is Kimbimba (Tilda) rice scheme where yields are high (3.5-4 tons/ha/season) and the system is well managed. Community participation and benefit is limited as it is a privately run site.

Table 5.24 Identified BP Sites in Uganda

UGANDA

Water Harvesting Sites

Site; Ownership	District	Type	Use
Kyalulangira, Kiziba and Kyalulangira village (community)	Rakai	FCT, 40m3	Domestic
Kamubisi village (community)	Isingiro, Kikagati Sub county	Partially Underground FCT Tank (80m3)	
Kyanyanda village Rugaga sub county (community)	Isingiro	Open underground Tank Circular (180 m3)	Crop Production
Edward Kanyarutokye, (individual)	Isingiro, Masha Sub county	FCT 12 m3	Domestic
Ekiryotozi (community)	Kiruhura, Kashongi sub county	Valley tank (10,000m3); Hand pump	Domestic; Watering animals
Kyamuyimba (community)	Luwero, Kamira sub county	Valley Tank (10,000 m3)	domestic, watering animals

Community Managed (Small Scale) Irrigation Sites

Site; Ownership	District	Crops
Iganga (Farming Community)	Iganga	Rice
Pallisa (Farming Community)	Pallisa	Rice
Tororo (Farming Community)	Tororo	Rice
Mr.Sembusi Richard, Bulenge Village (Private/community)	Masaka, Buwunga sub county	Coffee, banana, pineapple, coffee nursery, fish pond
Mr. Mpinde Livingstone, Katolerwa village, Private	Masaka, Kibinge sub county	Coffee, coffee nursery

Best practice sites for large scale irrigation

Site; ownership	District	Crops
Mubuku	Kasese	Onions Vegetables Alfalfa
Kimbimba (Tilda) (Private)	Bugiri	Rice
Doho (Community/public)	Tororo (Butaleja)	Rice
Kiige	Kamuli	Citrus
Ongom	Lira	Citrus
Labori	Soroti	Vegetables
Atera	Apac	Rice, Vegetables
Agoro	Kitgum	Rice, Vegetables
Olweny	Lira	Rice

Part IV: Inventory/Profile of Institutions in the Nile Basin

In order to upscale and support the concept of Best Practice in the Nile Basin countries, the support of Government, training institutions and research organisations/stations is needed. This section provides an overview of the institutional setup and legal framework within the Nile basin and draws upon the information provided in the RBA and BP reports. It establishes by country institutions that have a potential for assisting in the development of Best Practice and also for twinning with National Institutions to encourage the development of water harvesting and community irrigation activities including the sharing of data and information. This information is not comprehensive enough and will be expanded upon during Phase 2 of this assignment. The lead in this must be taken by National Governments, on whom much of the institutions rely for their funding. This is one of the issues that will be raised and has been flagged for attention in the validation workshops to be held in each country at the start of Phase 2. The needs of institutional and support in the improvement of water used in the Nile basin will lead into the recommendations in Part V.

.5 INSTITUTIONAL AND LEGAL FRAMEWORK

5.1 Institutional Reform Processes in the Nile Basin Water Sector

Examination of the strengths and weaknesses of the irrigation and water harvesting sector in the Nile Basin countries has shown that the institutional framework and the institutional arrangements at field level are overriding factors that govern success and sustainability. Many sound technical approaches are available but if they not well discussed with beneficiaries, will not be framed within their ability to manage them and without adequate follow-up advice and support, then they will not succeed.

Over the last two decades, most Nile Basin countries have either undertaken or are in the process of completing water sector reforms (Table 6.1). One aspect has been to update the water law to reflect changes resulting from a greater demand on water and the need to more clearly support irrigation and drainage developments with the creation of Irrigation Acts. The regional trend is decentralisation and commercialisation/privatisation of management, operation and maintenance (MOM) of water services. Whereas this fits well into the water supply sector, in the agricultural sector in which some of the players are extremely poor and located in relatively remote rural areas, this is not such a simple process. New laws impact on attitude and the assumption that water is no longer supplied by central government but free to all. Such changes may not necessarily reflect the rights and interests of traditional water users. None of the water sector reforms that have taken place in the Nile Basin include rainwater harvesting as an element of multi-sourcing strategy. It is hope that the process of water sector reforms will overcome the poor sector coordination that has hampered irrigation development with duplication of efforts and approaches. Establishment of national, regional and international irrigation networks and associations to enhance synergy and coordination in the sector has been started in a few countries, but needs more political support and understanding to gain the necessary impetus.

There is a wide diversity in institutional capacities of the water sector in the various riparian states and the level of development varies greatly. The capacity for successfully developing the approaches varies and data and knowledge differ considerably. Support for these activities will normally be found within appropriate national research institutions/universities but some are lacking. Considerable scope exists for the improvement and sharing of approaches within the Basin and this has already been initiated. Improvement of the Institutional aspects is being dealt with under the separate component of NBI. From Table 6.1, it can bee seen that Kenya, Tanzania and Ethiopia have made most progress in developing river basin organizations.

Kenya has established regional Water Resources Management Authorities and Water Services Boards for the six main river basins. Tanzania has formed Basin Water Boards and Basin Offices for the nine main river basins. Ethiopia has established a River Basin Authority outside the Nile Basin and a River Basin Authority for the Blue Nile. In the other riparian countries, the river basin is acknowledged as the appropriate management unit for IWRM; however this has yet to result in the establishment of water resources management organizations at basin level.

Table 6.1 Institutional Reform Processes

Country	National Water Authority	Decentralization	Consultation Platforms	River Basin organizations	Water Users organizations
Burundi	Different ministries	Ongoing discussion	National level	Ongoing discussion	Ongoing discussion
DRC Congo	Different ministries	Ongoing discussion		Ongoing discussion	discussed
Egypt	Different ministries		Piloted at district level	Ongoing discussion	Legal framework for WUA only
Ethiopia	One water ministry	State and district level	State and district level	One established and one prepared	piloted
Kenya	One water ministry	Basin level	Basin and catchment level	Six authorities established	Legal framework established
Rwanda	Different Ministries, Ministry of Water and Mines	Local government authorities; Private sector.	Basin and catchment level; District Level.	Ongoing discussion	piloted
Sudan	One water ministry	State level	Federal level	Two Advisory Committees	Legal framework for Gezira scheme
Tanzania	One water ministry	Local government authorities	National and basin level	Nine offices and boards established	Legal framework not yet established
Uganda	One water ministry	Local government authorities	National and district level	Lake basin authorities	Legal framework established

Source: Adapted from "Needs Assessment and Conceptual Design of the Nile Basin Decision Support System Consultancy, Draft Inception Report, 1 October 2007."

5.2 Institutional Responsibilities

With the changing thrust of governments from implementer to facilitator and with the devolution of many powers to local governments, the roles and responsibilities and relationships between the various players needs to be redefined. In all countries in the Nile Basin, water resources management mandates are increasingly assigned to one ministry that covers both water resources management and public services provision. However, the role of water harvesting and catchment management in this process has not been clearly defined. Constitutional and organizational functions are divided between the central ministry and water resources management authority along hydrological boundaries of river basins, but this now needs to extend to the sub catchments with water harvesting also included. These reforms have provided consultation platforms with public, private and voluntary organizations engaged in water resources management and for the coordination of initiatives and water resources management decisions (particularly in times of water shortages). All riparian states are supporting participatory processes at local level to ensure that services in the water sector relate more closely to bottom level demands. Management responsibilities for water supply and irrigation systems (Table 6.2) are being devolved to local levels to ensure that beneficiaries relate more to the services received and understand the need to contribute more to the management and maintenance of systems if they share in the ownership.

5.2.1 Irrigation and Drainage

Although most countries have irrigation organisations at scheme and community level, few have national institutions through which they can discuss successes, failures and needs as well as sharing experiences. A mechanism is needed through which users can influence many of the decisions made on their behalf. A far greater dependence upon irrigation will exist in the future, and responsible organisations with national experience need a much higher profile to provide the thrust required to guide and influence the direction and impact of irrigation in the country. Districts or regions in many cases do not have the capacity or experience to prioritise or assess irrigation developments nor do they have direct links with key central line ministries. These can provide assistance and guidance in irrigation related matters, but with the lack of defined formal links between local governments/regions and the responsible Ministry, if the former chooses to ignore this advice or cut corners, it is difficult for experienced Ministry technical staff to intervene, to ensure sound investments and practices that meet and conform to national priorities. The problems faced in this respect are evidenced by the current downplaying of the role of irrigation in both poverty reduction and food security.

Table 6.2 Water Resources Responsibilities in Riparian Countries

Country	Remarks
Egypt	Egypt prepared its first water resources policy after the construction of the Aswan High Dam in 1975. The policy has regularly been reviewed and updated. In 1993 the new water policy included several strategies to ensure satisfying the demands of all water use sectors. In 2004 the Ministry of Water Resources & Irrigation (MWRI) formulated the National Water Resources Plan (NWRP) that embraces the concept of Integrated Water Resources Management (IWRM) through a policy for dealing with the water scarcity challenges that will be facing Egypt in the 21st century. The NWRP provides specific actions in the form of an investment plan up until 2017. The current challenge is how to mobilize the required financial resources to implement the NWRM
Sudan	The Federal Ministry of Irrigation and Water Resources (MIWR) formed in 1999 became responsible for developing policies, strategies, legislation and plans for developing the national water resources. It is a multi-disciplinary and multi-sectoral committee to review, integrate and update the 1992 Water Policy. The committee prepared drafts that were discussed with stakeholders and the water related federal ministries and state governments, but failed to obtain approval. The 1992 Water Policy is still the official document. The general objective of the Sudan National Water Policy Draft of 2000 (SNWP) is to ensure that Sudan's water resources are properly managed, protected and efficiently utilized for the benefit of the Sudanese population
Ethiopia	The Federal Ministry of Water Resources formed a multi-disciplinary committee tasked to prepare a comprehensive and integrated Water Resources Management Policy. The committee had representatives of various Federal Ministries involved in the water sector and of State Governments. The draft policy document was in-depth discussed with representatives of the regional Bureaus of Water Resources Development and stakeholders of the private and voluntary sectors involved in the water sector. The overall objective of water supply and sanitation policy is to enhance the well-being and productivity of Ethiopian people through the provision of adequate, reliable and affordable clean water supply and sanitation services that meet livestock, industry and other water users' demand. The overall objective of the irrigation policy is to develop the irrigated agriculture potential for production of food crops & raw materials needed for agro-industries in a sustainable way. Water Resources Sector Strategies have been developed with short, medium and long-term sector development programmes prepared for 2002-2016. The strategies include; financing of water resources management & development, creation of an enabling environment, trans-boundary river management; stakeholder participation and gender mainstreaming; disaster prevention and public safety & environmental health standards.
Kenya	The Water Act 2002 granted the overall responsibility for water management in Kenya to the Ministry of Water Resources Management and Development (MWRMD). The Water Act introduced key reforms to the legal framework for the management of the water sector in Kenya which ware: a) separation of the management of water resources from the provision of water services: b) separation of policy making from day to day administration and regulation; c) decentralization of operational functions to lower level state organs; d) the involvement of the non-government entities and communities in the form of Water Resources Users Associations to manage water resources and provide water supply and sanitation services. The Water Master Plan (1992) provided the basic policy framework for Kenya. The plan was updated in 1998. The two semi-autonomous bodies that have been established for the organizational functions of water resources management and water services delivery prepared the National Water Resources Management Strategy and the National Water Services Strategies (2005-2007). The overall goal of the NWRMS is to eradicate poverty through the provision of potable water for human consumption and of water for productive use. Specific goals of the strategy are to improve equal access to water resources for all Kenyans; to promote integrated water resources planning and management at catchment basis; and to enhance the availability of water resources of a suitable quality and quantity.

Uganda	The Government of Uganda created through the National Environment Management Policy (1994), the Water Statute 9/1995 and the National Water Policy (1999) a policy framework for the water sector. The policies have strategies to enhance property rights, to promote environmentally sound land use, to enhance water resources conservation and management; to improve wetland management, and to apply environmental economics and incentives. The statute established the National Environment Management Authority, which in consultation with the leading agencies is mandate to issue guidelines and prescribe measures and standards for the management and conservation of natural resources and the environment. The Water Statute 9/1995 has the objective to allow for the orderly development and use of the water resources for domestic, agricultural and industrial purposes in a manner that minimizes harmful effects to the environment. Domestic use included irrigation of subsistence gardens not exceeding 0.5 ha. Extraction of water from surface or ground water is prohibited unless authorized. The National Water Policy proclaimed the formation of a central authority, being the Ministry of Water, Lands and Environment, whose role is to initiate national policies, to coordination between the line ministries, overseeing compliance and to provide technical support services. The policy aims to enhance the role of the private/voluntary sectors through the formulation of policy committees on environment & water at national and local level. These committees aim for active involvement of local authorities, private sector and NGOs in the development & management water supply & irrigation systems. Uganda has developed a framework for water resources management consisting of national legislations and by-laws for promoting sound water resources management and constrains potentially harmful practices. Water Resources Regulations, Water Supply Regulations and Waste Water Discharge regulations are all in place.
Tanzania	The new National Water Policy (NAWAPO) of July 2002 is the outcome of a review of the national water policy of 1991. The review was carried out under the River Basin Management and Smallholder Irrigation Improvement Project (RBMSIIP) and the new policy incorporated the principles of IWRM that were initiated by the Dublin Water Conference. In July 2002 the Government of Tanzania issued the National Water Policy whose main objectives were to establish a comprehensive framework: for sustainable development and management of water resources and for participatory agreements on the allocation of water uses. The policy incorporated the decentralization drive that was launched by the Local Government Reform Programme. The Ministry of Water became responsible for the constitutional and organizational function and the operational function was delegated to Local Government Authorities. Basin Water Offices were established to coordinate water resource management between the Regional and Local Government authorities at river basin level. In February 2005 the Government issued the National Water Sector Development Strategy 2005 to 2015.
Rwanda	The Government of Rwanda formulated it first National Policy on Water Management in 1994. The mandate of water resources management rested under various ministries (Agriculture and Public Works) before it was brought under the Ministry of Lands, Environment, Forests, Water and Mines (MINITERE). The policy formulation process reflected global policy changes and opened the sector for public, private and voluntary sector partnerships and references were made to Integrated Water Resources Management (IWRM) principles. In 2004 the Government of Rwanda held discussions with interested stakeholders and produced a water sector policy document that merged the water sector with lands environment and forestry sectors under MINITERE. The water sector policy was agreed by the Council of Ministers in October 2004. The new water policy introduces an institutional reform process in which a National Commission of Water, interdepartmental coordination, basin and catchments committees, and local water users associations are foreseen to be established. The public sector at sub-national level is expected to collaborate with the voluntary and private sector to manage the water resources and to provide water and sanitation services. The existing informal water users groups that manage local water resources will be organized into catchment committees and water user associations to ensure participatory processes in the planning and management of water projects and programs.
Burundi	The Government of Burundi formulated it first National Master Plan in 1992. The National Water Policy (NWP) and Strategic action plan was completed in 2001 to manage the national water resources in an integrated and sustainable manner. The accompanying Action Plan indicated objectives, actions, performance indicators, institutional responsibilities, budgets and an implementation calendar. The Ministry of Land Management, Environment and Tourism were the overall coordinator, and the Geographical Institute of Burundi was the technical coordinator of the Action Plan that anticipates participation by public sector and local communities through communal administration. However the NWP has never been presented to the Parliament to be accorded to a legal status. The NWP defined rivers, lakes, springs, groundwater, swamps permanently covered with water, islands, hydraulic structures constructed for the purpose of public benefit as public domain resources managed by the Ministry of Land Management, Environment and Tourism. No water intake or water effluent as well as the related water structures can be built in this public hydraulic domain without an authorization or a concession of the national water administration. However water can be abstracted freely from the ground or surface water for domestic purposes (human food supply, hygiene, washing, plant and animal production for domestic consumption). The law also establishes a priority order for the different water uses. Domestic water use enjoys the highest priority, followed by agricultural uses. The later cover water demands of livestock, fisheries and irrigation. These uses are followed by industrial, environmental and recreational water uses in declining order of priority. The holders of the water use rights have to use the water in a rational and economic way as well as to respect the rights of the other legitimate users. The water administration manages the water release of reservoirs on the basis of water needs, hydrologic and meteorological data and can decrease the discharge in case of water shortages.

Congo (DRC)	The Government of the Democratic Republic of Congo has no unified official water policy in place. Efforts to develop a water policy or a water code with support of UN-organizations have been less successful. There is not single organization responsible the governance functions of water resources management. The functions are shared over various Ministries and the Directorate of Water Resources within the Environmental Department of the Ministry of Environment, Water and Forest is responsible for the development of water policies. However the administrative and managerial capacities of the directorate are limited for its constitutional function. The National Action Committee on Water and Sanitation is responsible for coordination between the ministries and for balancing competing interests in water uses. The committee cannot take the function of water administration that has overall responsibility. The Committee could take an advisory role, however the compromises between conflicting interests would require an organization that has a clear mandate.

Decentralization of irrigation and water supply services to the lowest management level is being followed with different stages of progress in all riparian countries. Some initiated a radical public sector reform that decentralized the operational function for services provision to the lowest administrative level (Ethiopia Kenya, Uganda, and Tanzania); others adopted a more gradual approach and proceeded with pilot projects implemented with support of international development organizations. Institutional responsibilities for water used in agriculture has often been changed over night by governments without adequate discussion with involved technical staff and this created a negative and demoralising response from the staff that acted against continuity of investments.

5.2.2 Water Harvesting

Responsibility for water harvesting normally falls under the Ministry of Agriculture (MOA) in the Nile Basin countries as it takes place at community level and is the only organisation that has staff at filed level. In many cases, some confusion has existed on overall responsibility and interventions have often taken place by several different ministries with coordination being less than desirable and with different approaches and manuals being followed. Other than in-situ techniques, support for water harvesting has not been widespread at government level and has normally been supported by the informal NGO sector working with regional/district offices of government and not necessarily the central ministries. National water harvesting associations have been involved with the NGOs as they have links with the expertise needed for working with the communities and local government.

Issue/Constraint: *Water harvesting needs to be brought to the front of the national agendas on water resources management with adequate institutional support to ensure that interventions are not sidelined and that responsibilities are clearly defined.*

5.2.3 River Basin and Water Users Organizations[137]

As mentioned in section 6.1 some countries have made better progress than others in developing River Basin Organizations. In all riparian states water users groups and associations are promoted for participatory approaches in irrigation management. The rights and obligations of these organizations are in the process of being tested and uniformly defined. However, with the exception of Sudan and Egypt, a legal framework for water users associations and the up-scaling from local to supra-local level has yet to be developed. In Sudan, the Gezira Act (2005) has been adopted by the Federal Parliament and this provides sweeping responsibilities to WUAs. However, the irrigation officials and the leaders of these organizations have been poorly prepared for the radical institutional changes and therefore the Gezira Act encounters major implementation problems.

[137] More detailed information is contained in *Needs Assessment and Conceptual Design of the Nile Basin Decision Support System Consultancy, Nile Basin Initiative Water Resources Planning and Management Project Decision Support System (DSS) Component, Draft Inception Report, Consortium lead by hydrophil - consulting & knowledge development GmbH, October 2007*.

5.2.4 Irrigation Organisations[138]

Strong and functional farmer-based institutions are a pre-requisite for sustainable management of irrigation schemes. Weak irrigation water users' associations have contributed to the past poor performance of schemes. Membership of Irrigation Organisations (IOs) has not been fully understood or accepted by all irrigators. Farmers have often opted for irrigation cooperatives that are not single issue, but deal with the full range of activities relating to scheme development. Membership of cooperatives cannot and will not be compulsory. However, for non-profit organisations entrusted with water service delivery and O&M of irrigation schemes, membership needs to be compulsory as all land owners within the command area derive benefits from water supplied. All need to contribute equitably to ensure its continued supply and that water rights charges and O&M fees are met in full.

Issue/Constraint: *Review of the laws that are currently used for forming IOs is needed to adapt them to non-profit making organisations for solely managing the schemes. This will form part of the irrigation policy and must cover levels of water charges, water rights for irrigators and all related issues.*

Traditional irrigation developments are run informally by farmers through crisis management with irrigators coming together when problems such as excessive water shortage need addressing. Due to the evolution process of these schemes, no proper agricultural production calendar or fund for scheme repairs and other maintenance exists. In improved schemes, more formal established IOs exist and fall into three categories: irrigators' cooperative society; irrigators associations; non-registered associations**.** IOs are private organizations formed, registered and owned by the irrigators themselves to operate and maintain their scheme. Decisions are made by an elected committee on behalf of members and cover routine aspects such as how and when maintenance should be carried out through to monitoring of water abstractions and dealing with violators. Schemes sustainability depend on the strength of IOs to meet members' needs particularly regarding crop production and marketing, budgeting for O & M and payment for water rights charges. Support to IOs takes place at District level and includes responsibility for existing unimproved traditional or modernised schemes and already assisted schemes or those identified for assistance. Methodologies for providing this support need careful consideration and much information exists in each riparian country that needs to be shared.

should link with scheme or community extension agents offering day-to-day assistance in both irrigation and water harvesting. They will be responsible for assisting farmers in formulating/upgrading IOs and in implementing related activities.

5.3 Stakeholder Participation

5.3.1 Key Stakeholders/Organisations involved in RWH and Irrigation Development

Past irrigation development has rested primarily in the public sector, with private sector support for large-scale development of schemes for production of sugar and tea. After independence, many countries decided to bring ownership into the public sector and these in most cases were not sustainable decisions. Depending upon the size and type of interventions and the financial resources needed, the interested parties and stakeholders will vary. In most cases the key stakeholders include both public and private sectors together with those

[138] This will include Water User Associations and the nomenclature used and approach varies between the Nile Basin countries.

organisations supporting the financing of the interventions (State, donors or the voluntary sector - NGO). The broad range of stakeholders with interest in water harvesting and irrigation are presented in Table 6.3. This information has been derived from many sources, but still needs verification by the country authorities during the validation workshops. Information is listed by category and level of interest.

5.3.2 Private Sector Involvement

From the end of 1980s, the irrigation sector in all Nile Basin countries has been undergoing radical changes such as privatisation of the marketing chains, irrigation management transfers to farmers, adoption of cost recovery policy and emergence of environmental concerns. During the same period, donors' support to irrigation development has been decreasing with the main reasons advanced being low irrigation performance and poor sustainability of existing irrigation schemes. Currently, new and improved irrigation development is driven by the private sector whereby private commercial investors and smallholders are the main suppliers of fresh horticultural produce, fruits and floriculture for both the domestic and the export market, mainly to the European market. Through this investment over the last decade, Kenya has become one of the major fresh horticultural producers and flower exporter to the European market. The size and purchasing power of the country's major urban centres, the availability of low cost irrigation equipment and the will and adaptive capacity of farmers are the main factors for the vigorous development of smallholder private irrigation schemes.

The role of irrigation in agricultural production has not been well appreciated by Donors mainly due to the poor performance of the larger scale schemes and a lack of sufficient understanding of the issues involved. Small scale community irrigation developments have been more successful, but there has been a tendency of Donors to follow blue print solutions rather than fully involving beneficiaries and equipping them with appropriate enabling legal frameworks and site specific support. The low investment in irrigation in these small schemes aimed at local markets by the private sector reflects the lack of an enabling environment in which the relatively high cost of irrigation development and equipment cannot be financed by the returns received. Achievements in the irrigation sector have been attributed to a number of players both in public and private sector. Several studies have been made on irrigation but there has not been a forum for exchange of ideas among the major irrigation stakeholders.

Issue/Constraint: *In order to create an enabling environment to encourage, promote private sector and community investment in the irrigation and water harvesting sector, governments need to consider tax holidays for suppliers of irrigation services, equipment, and materials and a revision of energy and water tariffs for irrigation and water harvesting. This should be coupled with development, promotion and utilization of appropriate low-cost and efficient irrigation and water harvesting technologies.*

Table 6.3 Identified Stakeholders/Institutions for Support of Best Practices

Type of Organisation	Remarks	Interest (1=primary; 2= secondary)			
		RWH	SSI/ CMI	PPMI	LSI
Formal WUAs and informal/traditional community groups		1	1	2	1
Farmers organizations					
Cooperatives					
Irrigation Scheme Management Companies	Depends upon scheme management/level of devolvement	2	1	1	1

Water Resources (& hydropower) development) (MWR)	Grouping of ministries depends upon country, but in general water harvesting is with MoA and Irrigation is under the MWR.	2	2	1	1
		2	1	1	1
Irrigation & Drainage		1	1	2	2
Agriculture (MoA)		1	1	2	2
Rural Development		1	1	2	2
Livestock		1	1	1	1
Environment		1	1	1	1
Land		1	1	2	2
Fisheries		1	1	1	1
Forestry		1	1	2	1
Finance		2	2	1	1
Mining/Groundwater Local Government		1	1	1	1
National Irrigation Boards	Structure varies by country and level of involvement of Private sector	2	2	1	1
Water Resource Management Authority (WRMA)		2	1	1	1
Regional Development Authorities		1	1	1	1
Tea, Sugar and other large crop specific estates		2	2	1	1
World Bank; Danida; SIDA, CIDA; USAID, GTZ, IFAD, ADF, JICA, FAO, Irish Aid; French Embassy; European Commission; African Development Bank; UN Habitat; UNESCO; UNEP; et al.	Most donors are involved in some way in each of the Riparian countries. Emphasis is changing but only a few are involved in the larger irrigation developments.	1	1	1	1
CRS; CARE; CONCERN; World Vision; German Agro Action; OXFAM; Africare; ACORD; Action Aid; Cooperazione Internazionale (COOPI); Goal; Food for the Hungry International; International Rescue Committee; Lutheran World Federation; Norwegian Church Aid; PLAN International; Self Help Development International; Water Action; Water Aid; et al.	These NGOs are involved in a number of NBI countries with RWH and support to SSI being part of a larger portfolio that relates to poverty reduction and community support	1	1	2	2
Rocker Feller Foundation	Kenya	1	2	2	2
Sudanese Society for Community Tree Planting	Sudan	1	2	2	2
ACORD; Action Contre la faim; LVIA; SOPRAD;COPED; CICR	Burundi	1	1	2	2
Ethiopian Catholic Secretariat	Ethiopia	1	2	2	2
Ethiopian Orthodox Church/ DICAC	Ethiopia	1	1	1	1
National Rainwater Harvesting Associations	These are the main organisations. Others will exist, but there is a need for the appropriate organisations to maintain standards and ensure adequate training and professional development.	1	2	2	2
Crop Protection Societies		1	1	1	1
Civil Engineers Association		1	1	1	1
Societies of Soil Science (ESSS)		1	1	1	1
National Water and Sanitation NGO Network (WASNET)		1	1	2	2
Development & Agricultural Banks	Financing larger groups	1	1	1	1
National and Other Banks	More support to smaller groups.	1	1	1	1
Equipment Suppliers	Irrigation and drainage Pumps; Irrigation Equipment; Treadle pumps; etc.	1	1	1	1
Consultants and Service Providers	Both National and International	1	1	1	1
See Separate lists	All countries have specialised institutions, but need revised curricula.	1	1	1	1
See Separate lists	Egypt dominates with many institutions, but only a few are suitable for the upper Nile Countries.	1	1	1	1

Stakeholder participation in water harvesting and irrigation is achieved for some projects, but not yet at a national level. Some riparian countries have created national platforms in which the stakeholders at national level are consulted on important policy issues and water resources management decisions, but lower level stakeholders on whom much of the implementation depends are not yet well represented or organized. The National Project Coordinators assist with wider involvement and dissemination, however, as this is a part-time post for EWUAP, the time and resources that they can commit to this are limited. In Kenya, Tanzania and Sudan platforms for stakeholder consultation in water resources management have been formed at sub-river basin level. At these levels conflicting interests in water resources uses have to be resolved during periods of water shortages and the platforms have a function in creating constituencies for the water resources management decisions. In Ethiopia the River Basin Authorities have a legislative body in which the federal and state governments are represented and stakeholders from the private and voluntary sector have observer status. In Egypt and Uganda, District Water Boards and District Water and Sanitation Coordination Committees respectively are formed as platforms to represent the private and voluntary sector organizations interests through direct consultation with water managers at district level. In Egypt, Federations of WUA are being piloted at branch canal and primary canal level. These federations are involved in decision making for the planning of maintenance activities and the resolution of disputes related to the water distribution between up-and downstream water users.

5.3.3 Stakeholders' Perception of Main Issues

Many stakeholders have a different perception of risk to those attributed to them by planners. The reluctance of communities to take over MOM of irrigation developments has been due to their assessment of risk. Communities know well the problems within their own command areas and need to be properly convinced that any interventions proposed will overcome these identified risks. An examination of the performance of support to small-scale irrigation within the Nile basin has shown that beneficiary concerns relate to (i) their ability to pay for and manage the system proposed, (ii) their inability to access key technical support and advice when needed, (iii) the lack of financial support to enable them to follow recommendations made, (iv) the lack of suitable markets within reasonable distance from their farms, (v) poor linkages between crops grown and markets for them, (vi) insufficient access to improved varieties of seeds and other inputs, (vii) poor control of other users of the same water resources resulting in competing water uses/deficits, (viii) insufficient funding of O&M and rehabilitation (and upgrading) and (ix) top-down management without participatory planning and management capacities.

5.3.4 Cost Recovery

Changes in the approach to water management include charging for water use to recover costs of services. In all riparian countries the new water resources policies aim for cost recovery for the management costs of irrigation and water supply and sanitation services. Recovery of O&M costs is becoming a common practice both in urban and rural water supply and urban sewerage water treatment. However, the poorer segments of the urban society and rural communities face problems with paying the water fees for drinking water let alone irrigation. Mechanisms for improving the cost recovery performance and subsidies for the poorer segments of these societies are currently lacking with the private sector (including the rural agricultural communities) increasingly requested to contribute to the investment costs of irrigation and drainage systems. Experiences show that under the current conditions this is only viable when high-value horticultural crops are cultivated for urban areas and export.

5.4 Policy

Improvement in the use and productivity of water for agriculture requires appropriate enabling policies including acts and bylaws. As mentioned above, the current enabling environment in almost all of the Nile Basin countries is not yet sufficiently developed. Water abstraction licences if permitted by law are rarely closely monitored and controlled. Many irrigation organisations cannot obtain loans and credit from banks as the appropriate supporting legislation is currently lacking. Cooperative law although generally considered to be sufficient for this purpose, has proven to be too general to meet the needs of irrigation and water harvesting groups. The lack of a national irrigation policy, legal and institutional frameworks for irrigation development has been a bottleneck. The fact that water harvesting has not been considered in such a policy has shown the need to rethink the requirements for these policies across the Nile Basin. Water pricing is part of this process, but is needed not so much to improve irrigation water use efficiency, but to assist users to recognize the importance of water in their productive uses as well as financing the arrangements for equitable sharing and use in times of shortages.

5.4.1 Irrigation Policy

In most Nile Basin countries, the overarching constraint to irrigation development is the lack of a clearly defined policy to guide developments. This impacts over the whole sector and permits short-term changes in direction and support that are often unsubstantiated and lack a coherent direction and defined investment priorities. Past irrigation developments have been characterised by the policies of those donors who have been supporting them and this has resulted in a lack of clear cohesion of objectives and sudden changes that put an undue burden on government. The establishment of infrastructure for Irrigation development can be achieved within a 5 year time frame, but the associated software support to ensure its sustainability requires much longer. Appropriate irrigation policies can ensure the continuity of support that this needs and the issues that such a policy needs to address to include: (a) Establishment of a firm role for irrigation in the National economy based on the contributions that it makes, (b) guidelines for investment plans in the sub-sector, (c) Prioritisation and facilitation of irrigation development activities in the country, (d) Establishment of methodologies for future support to both existing and new irrigation schemes using the recent experiences from a number of successful projects, (e) Mechanisms to ensure that established processes are followed leading to adequate preparation for assessing irrigation developments using District level teams, (f) Definition e roles and responsibilities of different institutions and their relationships with the District level planning process and thereby delineation of institutional responsibility for different levels of irrigation and interventions, (g) Integration of donor support into the prioritisation process ensuring compatibility of interventions and that all support to the sector follows agreed processes, (h) Specification of the need for an Irrigation Authority with the responsibility to designate irrigation areas/districts, which transcend village-district-regional boundaries, (i) arrangements for dealing with concerns raised relating to the impact of irrigation development on the other sectors/sub-sectors such as environment and utilization of water resources/water rights.

5.4.2 Water Harvesting

Only Rwanda has laws that deal with domestic roof water harvesting (DRWH) and the direct collection of roof runoff and storage for later use. In all other countries, the use of water harvesting is implicit within the water laws but not explicitly dealt with. In many cases, the users are happy to accept the status quo until the introduction of water charges takes place as has happened in Kenya. Private investments in stored water, and incentives for individuals to collect water near to where it falls for individual and community use, are not covered. Experience from South Africa is useful, as they have established the conditions under which privately developed water storage sites come under the control of district authorities. Practitioners are often rather glad to not wake up “sleeping dogs” and, instead of working on appropriate legislation, prefer to follow a strategy to first create facts without too much government involvement. By failing to consider water harvesting in legislation and policy, there is little encouragement for communities and individuals to provide the level of investment needed to create storage structures. While individual village-level RWH projects may succeed in the short term, their long terms sustainability may be severely tested in the absence of an appropriate institutional and legal framework at all levels. It is also unlikely that widespread replication of appropriate technologies and community based implementation strategies will be achievable in the absence of supportive institutions at higher levels, even if isolated project success may be possible.

In most of the Nile Basin countries, the right to the use of water is vested in government. In Ethiopia all water sources are the collective property of the Ethiopian people and are administered by the government. In Uganda, all water sources in rural areas now belong to the users (1995 Water Statute). In Kenya, a water act exists but implementation is vested with the appropriate Minister (irrigation and water resources). A similar situation exists in Uganda and Tanzania. In most other countries, the use of and the granting of permits for water use has fallen behind actual abstractions. In Tanzania this was addressed under the approach adopted by the RBMSIIP project and coupled with system improvements, was accepted by the water users who could see the increased benefits of having an overall organisation responsible for the river basin.

Under the water sector reforms, the aim is to ensure that users for portable water supply are fully metered with water billed according to consumption. This does not cater well for the poorer members of society who attach different values to different supplies of water and who change their sources depending upon availability, cost and reliability. Decentralisation of management relates mainly to O&M and does not give the option to communities to implement their own water harvesting policy using different water resources.

5.5 Research

Within the Nile Basin countries, there are many agricultural research centres (Table 6.4). These include both national institutions that have been set up for specific needs as well as those regional organisations formed to share experiences across the wider group of countries. Many of these institutions and research centres have been established to support rainfed agriculture and do not have close enough linkages with the beneficiaries for whom the support is targeted. To improve this situation, the Consultative Group on International Agricultural Research (CGIAR)[139] was established with the specific target of mobilising knowledge for the benefit of the poor. This alliance of international agricultural centres includes the International Water Management Institute (IWMI[140]) with its regional office based in Ethiopia that is undertaking several research projects on land and water management.

A number of ongoing and planned research projects being executed by several research organizations in the Nile Basin are pertinent to the NBI. Two CGIAR centres have their headquarters in Nile Basin countries: World Agroforestry (ICRAF), and the International Livestock Research Centre (ILRI), and most Centres, like IFPRI, World Fish, ICRAF working in areas of food policy, fisheries, forestry, are active in one or more of these countries. The Nile is one of the nine "*Benchmark Basins*" of the CGIAR Challenge Program on Water and Food (CPWF) that is researching on water productivity questions at river basin scale (see section). The Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) has its headquarters in Entebbe, Uganda and operates in nine out of ten riparian countries. It aims to sponsor creative, innovative, high quality regionally coordinated agricultural research that adds value to national programs.

5.6 Extension Services

One of the underlying problems to sustainability in irrigation and water harvesting developments has been the inadequate level of support from extension services and a lack of continuity in such services (see section 2.6.2 in Part II of this report). This stems from two main causes, a lack of investment and insufficient suitably trained and equipped extension staff. This includes both public and private sector. Although each riparian state has its own group of universities and colleges of higher learning (Table 6.5), in many cases the curricula is not closely enough related to the actual demands and field requirements of both the public and private sector when dealing with irrigation and water harvesting. All institutions need carefully examine their curricula and course content so that they reflect more closely the

[139] Includes 15 international agricultural research centres and is based in Nairobi, Kenya.
[140] IWMI's mission is to improve water and land resources management for food, livelihoods and nature.

market needs, particularly in relation to water harvesting and small-scale irrigation. Both Tanzania and Uganda have done well in modifying the curricula of the relevant universities and colleges with the result that they have attracted students from not only within their own countries but also within the region. The requirements of irrigation extension are often grouped together with rainfed needs and this is a mistake as the requirements for support in irrigation agronomy and irrigation extension require different emphasis and are much more site-specific. In Tanzania, the Department of Irrigation and Technical Services has appreciated this, in spite of resistance from Donors, and has set up in Igurusi a series of technical courses to meet the specific needs of irrigation and drainage development including extension needs.

Sustainable and profitable irrigation development requires a range of support services to farmers and their organizations. This necessitates investment in irrigation research and extension to improve crop productivity, water use efficiency and cost-effectiveness of irrigation development. These will need to include the following:

- Funding of applied research and extension activities;
- Coordinated research and extension;
- Dissemination of research findings;
- Additional research and extension personnel;
- Improvement of marketing infrastructure;
- Increased capacity to support irrigated agriculture;
- Introduction and adaptation of appropriate low-cost irrigation and water harvesting techniques and technologies.

Table 6.4 Identified Research Institutions within the Nile Basin countries

List of Potential Cooperating National Stakeholders/Institutions for Research - Egypt	
Stakeholders/Institution	**Expertise in relation to the needs of EWUAP**
Water Management Research Institute (WMRI).	It deals with researches relevant to distribution of irrigation water, modern irrigation systems, assessment of plant water requirements, and improvement of the irrigation delivery network, increasing irrigation efficiency and minimizing water losses. Monitoring and Evaluation of irrigation/agriculture schemes &Socio-Economic analysis;
Water Resources Research Institute (WRRI).	It works in the field of water resources development conducting studies on the possible projects to be implemented in the upper tributaries of the Nile River and in the Sinai Region, in addition to the establishment of a complete network of recording devices used in designing dams and other control structures, water harvesting activities in arid regions;
Field-crops Research Institute	The main goal of the institute is to increase crop productivity and quality to ensure food security, optimize use of natural resources (land & water); and use up-to-date technology to reduce input cost and increase net returns to the farmers; (i.e. CMI, activities).
Environment and Climate Research Institute (ECRI).	It established in 1994 to perform high level research on the impacts of both environment and climate change on natural resources, in particular water resources. The Institute activities are:-To Study the environmental impact assessment on water resources and other water development projects; To investigate short and long-term effects of climatic fluctuations on the environment and on water resources
Soils, water & Environment Research Institute:	Conducting studies and researches on: - Soil-water-plant relations, Soil survey and classification, Improvement and conservation of cultivated soils, Soil fertility and plant nutrition, Organic farming, Crop water requirements, Water suitability for irrigation, Designing and evaluation of field drainage networks, Reuse of marginal water in irrigation and Environment; (i.e. CMI, activities).
The Agricultural Research Center (ARC):	Created in the early 1970s. Over the past two decades, numerous achievements have been realized, including the development of new varieties, improved agronomic practices, livestock development, maintenance of the national herds and better food processing techniques. New crops and animal breeds have also been introduced and research has been dedicated to problem- solving, side by side with basic science. The overarching goal is to maximize the economic return per unit of land and water
Channel Maintenance Research Institute (CMRI).	
Ground water Research Institute (GWRI).	
Construction Research Institute (CRI).	
Mechanical and Electrical Research Institute (MERI).	
Survey Research Institute (SRI).	
Coastal Research Institute (CORI).	
Hydraulic Research Institute (HRI).	
Drainage Research Institute (DRI).	
Horticulture Research Institute:	
Agricultural Economics Research Institute	
Agricultural Extension and Rural Development Research Institute:	
Food Technology Research Institute:	
The National Water Research Center (NWRC)	
Agricultural Engineering Research Institute	
Regional Center for Training and Water Studies (RCTWS)	
Central Laboratory for Agriculture Research:	
Central Laboratory for Agricultural Expert Systems:	
Central Laboratory for Agricultural Climate: the major objectives are:	
Kenya Agricultural Research Institute (KARI)	
National Water Research Centre	
Nile Research Institute	
Hydraulics Institute	
Nile Research Institute (NRI).	
List of Potential Cooperating National Stakeholders/Institutions for Research - Ethiopia	
Stakeholders/Institution	**Expertise in relation to the needs of EWUAP**
Ethiopian Institute of Agricultural Research (EIAR)	Irrigation; horticulture development
(International Water Management Institute) IWMI	Irrigation water management best practices identification
The International Livestock Research Centre [ILRI]	
SASAKAWA Global – 2000 Ethiopia;	WH; conservation tillage; vertisol management
Ethiopian Horticulture Producer – Exporters Association	Efficient water use in the production of vegetables, herbs and fruits; out grower arrangement for cash poor farmers
MERET Project	Water harvesting, Integrated watershed development,
ERHA	Promotion of WH measures
List of Potential Cooperating National Stakeholders/Institutions for Research - Kenya	
Stakeholders/Institution	**Expertise in relation to the needs of EWUAP**
Consultative Group on International Agricultural Research (CGIAR)	

SWMnet/IMAWESA	
Jomo Kenyatta University of Agriculture and Technology	Well trained manpower in research and extension
University of Nairobi	Well trained manpower in research and extension
Egerton University	Well trained manpower in research. Active participation in planning and implementation of Lare water harvesting project
Maseno University	Well trained manpower in research/extension; situated in Nile Basin.
Kenya Rainwater Association	Experience in water harvesting and small scale irrigation. Good organizational skills in training and conferences/workshops
Kenya Agricultural Research Institute (Irrigation and Drainage Branch)	Well trained manpower in research and extension. Actively involved in irrigation research and development. Have developed irrigation operational manuals including drip irrigation.
Ministry of water and Irrigation	Trained manpower. Mandated to deal with technical and policy issues in irrigation development.
Ministry of Agriculture (Land Development Division)	Well training staff. Well established extension service that would make to implement water harvesting and irrigation projects
Kenya Meteorological Training Institute	Good training facilities and national data base on rainfall amount and distribution.
Lake Basin development Authority	Have been implementing irrigation projects in the Lake Basin
National Irrigation Board (NIB)	Well trained personnel in irrigation development. In charge of most of the Public managed irrigation schemes
Kenya Water Institute	Training and research
National Environmental Management Authority (NEMA)	Mandated to implement environmental laws against pollution and degradation, Environmental impact assessment on irrigation projects.
International Centre for Research in Agroforestry (ICRAF)	Applied field based research in partnership with farmers

List of Potential Cooperating National Stakeholders/Institutions for Research - Rwanda

Stakeholders/Institution	Expertise in relation to the needs of EWUAP
National University of Rwanda (NUR)	Irrigation and Drainage - Training and field demonstration: Faculty of Agriculture; Department of Soils and Environment Management; Post Graduate Diploma in Irrigation and Drainage
Faculty of applied Sciences (NUR)	Water resources and env. Management; Training and field demonstration
Rwandan Institute of Research	Rice and Horticulture; Field trials and research
Kigali Institute of Science and Technology	Irrigation and water harvesting; Training and maintenance of infrastructure
ISAE	Rural development engineering; Training and monitoring
Agro-Action Allemande	Training
Agricultural Engineering and Appropriate Technology Research Institute (AEATRI), Namalere,	

List of Potential Cooperating National Stakeholders/Institutions for Research - Tanzania

Stakeholders/Institution	Expertise in relation to the needs of EWUAP
Traditional Irrigation and Environmental Development Organization (TIP)	
Soil Water Management Research Programme at Sokoine University of Agriculture	on-going research activities include:(i) Improvement of soil fertility management practices in rainwater harvesting systems, (ii) Improving the management of common pool resources in rainwater harvesting systems, (iii) Smallholder system innovations in integrated watershed management (iv) Climate change adaptation for Africa. Outreach activities, training of trainers, professional capacity building and consultancy services.
Kilimanjaro Agricultural Training Centre	One scheme from each irrigation zone is used as model site whereby farmers acquire knowledge and skills in improved cultivation, water management, farming tools, cropping pattern, management of farmers' organizations, farmer-to-farmer extension, etc. KATC is recognized as the centre of excellence by MAFSC and donor.
Same Agricultural Improvement Programme	The NGO has collaborated with RELMA and SWMRG in construction of RWH structures. It is involved in many researches carried by SWMRG in Same District
Ministry of Agricultural Training Institute - Igurusi	Government Mid level Training Institute (Diploma in Irrigation)

List of Potential Cooperating National Stakeholders/Institutions for Research - Uganda

Stakeholders/Institution	Expertise in relation to the needs of EWUAP
Depart of Agricultural Engineering, Makerere University	Train, carry out research and outreach in Agricultural Engineering (including irrigation and water harvesting}
Agricultural Engineering and Appropriate Technology Research Institute (AEATRI), Namalere,	Carry out research and outreach in agricultural engineering
NARO	Specializations: hydropower, irrigation and water
Uganda rainwater Association (URWA)	Promotion of rainwater management and strengthen the capacity of members to implement rainwater harvesting activities
Uganda Water And Sanitation NGO Network (UWASNET)	Promote partnership between NGOs & other sector stakeholders in water and sanitation sector and to contribute to the development and implementation of sector policies, strategies and guidelines
Ministry of Agriculture Animal Industry and Fisheries(MAAIF)	Support, promote, guide production of crops, livestock and fisheries to ensure improved quality/ quantity of agricultural produce & products for domestic consumption, food security & export
Directorate of Water Development (DWD)	Promote co-ordinated, integrated and sustainable water resources and provision of water for all social and economic activities.
Kyera farm	To train community members in low cost technologies of roof water harvesting and promote integration of sanitation and RWH programmers in district and promote sustainable organic farming
Tilda (Kimbimba) Rice scheme	To sustain ably produce rice for commercial purpose

Table 6.5 Institutions of Higher Learning within the Nile Basin

Potential Institutions for Capacity Building and Twining Activities - Burundi	
Stakeholders/Institution	**Expertise in relation to the needs of EWUAP**
University of \Burundi (Bujumbura	
Potential Institutions for Capacity Building and Twining Activities - Egypt	
Stakeholders/Institution	**Expertise in relation to the needs of EWUAP**
Universities of Alexandria and Cairo	
Cairo University - Faculty of Engineering	well equipped facilities required for post graduate research with particular emphasis on topics related to the River Nile, irrigation systems, conjunctive use of Egyptian water resources, open channel and closed conduit flows, water quality monitoring and analysis, and also the environmental impacts of industrial processes
Ain Shams University - Faculty of Engineering	Irrigation Works, Drainage, and Land reclamation, Underground Water, Harbor Engineering, Coastal Engineering, Inland Navigation and the Environmental Science relevant to the above branches. The main aim of the Irrigation & Hydraulics Department is to graduate qualified Civil Engineers, in accordance with the country policies that pay much attention to the big water Projects.
List of Potential Cooperating National Stakeholders/Institutions for field level demonstration of best practices – Ethiopia	
Stakeholders/Institution	**Expertise in relation to the needs of EWUAP**
Ethiopian Institute of Agricultural Research (EIAR)	Irrigation; horticulture development
Addis Ababa University, Faculty of Technology	In-service training courses in hydrology
Alemaya University	WH, Irrigation: provides in-service training upon request; conducts research in irrigation;
Arbaminch University	Irrigation: provides in-service training upon request; conducts research in irrigation;
Debub University	Training in plant production and dry land farming
Jimma University	Irrigation; horticulture development
Mekelle University	Training in: dry land agriculture, irrigation
(International Water Management Institute) IWMI	Irrigation water management best practices identification
SASAKAWA Global – 2000 Ethiopia;	WH; conservation tillage; vertisol management
Ethiopian Horticulture Producer – Exporters Association	Efficient water use in the production of vegetables, herbs and fruits; out grower arrangement for cash poor farmers
MERET Project	Water harvesting, Integrated watershed development,
ERHA	Promotion of WH measures
Potential Institutions for Capacity Building and Twining Activities - Kenya Report	
Stakeholders/Institution	**Expertise in relation to the needs of EWUAP**
Jomo Kenyatta University of Agriculture and Technology	Well trained manpower in research and extension
University of Nairobi, Kenya	Well trained manpower in research and extension
Egerton University	Well trained manpower in research. Active participation in planning and implementation of Lare water harvesting project
Maseno University	Well trained manpower in research and extension and also situated within the Nile Basin.
Kenya Rainwater Association	Experience in water harvesting and small scale irrigation. Good organizational skills in training and conferences/workshops
Kenya Agricultural Research Institute (Irrigation and Drainage Branch)	Well trained manpower in research and extension. Actively involved in irrigation research and development. Have developed irrigation operational manuals including drip.
Ministry of water and Irrigation	Trained manpower. Mandated to deal with technical and policy issues in irrigation development.
Ministry of Agriculture (Land Development Division)	Well training staff. Well established extension service that would make to implement water harvesting and irrigation projects
Kenya Meteorological Training Institute	Good training facilities and national data base on rainfall amount and distribution.
Lake Basin development Authority	Have been implementing irrigation projects in the Lake Basin
National Irrigation Board (NIB)	Well trained personnel in irrigation development. In charge of most of the Public managed irrigation schemes
Kenya Water Institute	Training and research
National Environmental Management Authority (NEMA)	Mandated to implement environmental laws against pollution and degradation, Environmental impact assessment on irrigation projects.

International Centre for Research in Agroforestry (ICRAF)	Applied field based research in partnership with farmers
List of Potential Cooperating National Stakeholders/Institutions for field level demonstration of best practices – Rwanda	
Stakeholders/Institution	**Expertise in relation to the needs of EWUAP**
National University of Rwanda (NUR)	Irrigation and Drainage - Training and field demonstration: Faculty of Agriculture; Department of Soils and Environment Management; Post Graduate Diploma in Irrigation and Drainage
Faculty of applied Sciences (NUR)	Water resources and env. Management; Training and field demonstration
Rwandan Institute of Research	Rice and Horticulture; Field trials and research
Kigali Institute of Science and Technology	Irrigation and water harvesting infrastructure; Training and maintenance of infrastructure
ISAE	Rural development engineering; Training and monitoring
Agro-Action Allemande	Training
University of Rwanda (Kigali)	
Potential Institutions for Capacity Building and Twining Activities - Sudan	
Stakeholders/Institution	**Expertise in relation to the needs of EWUAP**
University of Gezira, Sudan	Institute of Irrigation and Water Management,
University of Khartoum	
List of Potential Cooperating National Stakeholders/Institutions for field level demonstration of best practices – Tanzania	
Stakeholders/Institution	**Expertise in relation to the needs of EWUAP**
University of Dar es Salaam, Tanzania	Department of Water Resources Engineering
	The Institute of Resources Assessment (IRA)
	University College of Lands and Architectures Studies (UCLAS)
Traditional Irrigation and Environmental Development Organization (TIP)	Registered as an NGO since 06/08/1999; The main focus of the NGO is to assist farmers improve smallholder irrigation practices based on sustainable use of land and water resources through: i) strengthening the organizational capacity of WUGs ii) improving land management practices iii) improving traditional irrigation systems iv) assisting in market access and agro-enterprise development.
Soil Water Management Research Programme at Sokoine University of Agriculture	Professional staff in irrigation, hydrology, soil science, agronomy, agric communication, agric and resource economics, agro met, GIS and remote sensing, S&WC, modelling soil and atmospheric conditions affecting plant growth.
Kilimanjaro Agricultural Training Centre	The centre offers specialised short courses in agriculture with special emphasis on irrigated rice farming. One scheme from each irrigation zone is used as model site whereby farmers acquire knowledge and skills in improved cultivation, water management, farming tools, cropping pattern, management of farmers' organisations, farmer-to-farmer extension, etc. KATC is recognized as the centre of excellence by MAFSC and donor.
Same Agricultural Improvement Programme	Improve irrigation structures, improve land productivity, and enhance capacity of community to manage water resource in a sustainable way, promotion through training of use of draft animal power in farm activities. The NGO has collaborated with RELMA and SWMRG in construction of RWH structures.
Ministry of Agriculture Training and Research Institutes (Tanzania)	At Ukiriguru in Mwanza; Mlingano in Tanga; Uyole and Igurusi in Mbeya; Naliendele in Mtwara; Maruku in Kagera and Tumbi in Tabora
Ministry of Agricultural Training Institute - Igurusi	Government Mid level Training Institute (Diploma in Irrigation). The institute offers diploma in irrigation (design and construction of small scale irrigation schemes, soil-plant water relationship, farming system approach, extension, etc) ; land use planning; general agriculture; and also tailor made courses to farmers (water management, paddy production, beans production, operation and maintenance irrigation scheme canals, environmental conservation, crop production, plant protection, soil and conservation issues, vegetable production, group formation and use of pedal pumps for irrigation)
List of Potential Cooperating National Stakeholders/Institutions for field level demonstration of best practices – Uganda	
Stakeholders/Institution	**Expertise in relation to the needs of EWUAP**
Makerere University, Kampala	Faculties of Agriculture, Forestry, Zoology, and Veterinary Medicine. Train, carry out research and outreach in Agricultural Engineering (incl. irrigation and water harvesting}
Agricultural Engineering and Appropriate Technology Research Institute (AEATRI)	Carry out research and out reach in agricultural engineering
Uganda Agricultural training colleges	Arapai, Bukalasa, Busitema (agricultural mechanisation) and Entebbe (fisheries)
Uganda rainwater Association (URWA)	Promotion of rainwater management and strengthen the capacity of members to

	implement rainwater harvesting activities
Uganda Water And Sanitation NGO Network (UWASNET)	To promote partnership between NGOs and other sector stakeholders in water and sanitation sector in Uganda and to contribute to the development and implementation of sector policies, strategies and guidelines
Ministry of Agriculture Animal Industry and Fisheries(MAAIF)	Support, promote and guide the production of crops, livestock and fisheries so as to ensure improved quality and quantity of agricultural produce and products for domestic consumption, food security and export
Directorate of Water Development (DWD)	Promote co-ordinated, integrated and sustainable water resources and provision of water for all social and economic activities.
Kyera farm	To train community members in low cost technologies of roof water harvesting and promote integration of sanitation and rainwater harvesting programme in the district and promote sustainable organic farming
Tilda (Kimbimba) Rice scheme	To sustain ably produce rice for commercial purpose

Part V: Sector Development Perspectives in the Nile Basin

The problems and constraints identified throughout the Nile Basin countries have been discussed in Part II of this report (Section 3) along with factors that contribute towards achieving more efficient water use and productivity (Section 4). In Part III, the types of best practice that would contribute towards improvements in water use and crop production were discussed in detail (Section 5) along with the institutional constraints that are inhibiting progress (Section 6). The issues and areas of concern highlighted are now considered below along with the opportunities that are available for addressing problems. Possible interventions that could be used to address the problems that arise are presented and these will be taken forward into the next stage of this assignment (Part 2). Suitable manuals for supporting water harvesting and small scale irrigation interventions in the Basin will be prepared with a view to meeting the needs of the riparian countries and to encourage a wider use of available knowledge and techniques within the Nile Basin countries. Some indicative ideas on future directions, possible opportunities and priorities for investment in agricultural water management that might be taken forward by the SAPs are also included. It is anticipated that these will be lead to interventions at the field level in terms of piloting or up-scaling.

.6 SECTOR DEVELOPMENT PERSPECTIVES

This overview has identified a wide number of constraints affecting agriculture and agricultural water use in the Nile Basin countries and also commonalities that exist. Water is not used efficiently within the basin and there is considerable scope for improving productivity through support to existing users and the upscaling of technologies and approaches used in some Nile Basin countries. The Nile Basin Commission, facilitated by the EWUAP project, provides an excellent vehicle for the sharing of ideas and experiences amongst the Nile Basin countries to enhance the effectiveness and profitability of investments in the sector. Priority areas for investments are emerging from the analysis of constraints and issues that arise (Table 7.1) and the way in which they are affecting irrigation development and water harvesting. These will be examined further during Phase 2 and are below together with the measures for addressing the issues raised include:

Overall (for both RWH and CMI)

a) Establishment of an Enabling Environment;
b) Mainstreaming of Activities and support into Governments Development Programmes.
c) Institutional Development and Capacity Building including Water Users Associations;
d) Presentation of appropriate technologies and approaches for wider use and upscaling;
e) Improved extension support including the availability of appropriate technologies;
f) Market development including linkages with buyers;
g) Training and support at field level;
h) Applied research;
i) Monitoring and evaluation of outcomes/results;

Water Harvesting

a) Improved and Integrated Water Resources Management (IWRM) with greater Community Involvement;
b) Consolidation of techniques available and wide dissemination of results;

Irrigation and Drainage Developments

a) Improved Water Service Delivery including Irrigation Service Fees;
b) Improved On-Farm Water Management including raising productivity and facilitating efficient water Use.

Full details of constraints and issues arsing are given in Tables 7.2 to 7.11 by sub heading with discussions on the causes and possible interventions.

For upscaling of the measures to support water harvesting and community managed irrigation, the Nile Basin can be divided into three areas:

(j) The Main Nile and the Blue and White Niles in Sudan;
(k) The White Nile Upstream of the Sudd Swamp;
(l) The Blue Nile Upstream of Sudan.

This division relates to topography and climate, the scale of the systems involved the experience of water users and the possible upscaling. Many of the experiences available from (b) and (c) can be applied to each other with the scale and support for interventions being similar. For (a), there are places where experiences from the upper Nile countries can be of benefit and visa versa, but a degree of adaptation will be needed.

In general, there are few experiences that can be transferred directly from the perennial irrigation systems of Egypt to the Upper Nile. Agronomic practices, research on crop varieties and other related issues will have useful applications for improving productivity in the upper Nile. Training approaches and facilities also will benefit areas (b) and (c). Water harvesting technologies and introduction modalities have wider applications and will result in a transfer of experiences. Many of the techniques available and to be fully documented will benefit all areas equally. During Phase 2 these will be examined in more detail to identify priorities by countries.

Table 7.1 Constraints to Agriculture, Irrigation Development and Rainwater Harvesting

General	Agriculture	Irrigation and Drainage systems	Water Management and Productivity	Finance and Funding	Extension Services
Increases of urbanization	Increase in cultivated area below the rate of increase in population	I & D Developments	Water management	Development costs	Inadequate extension services to support I&D and RWH developments.
Declining landholding sizes	Poor adoption of technical packages for production	Condition of Irrigation & Drainage systems	Irrigation Efficiencies	Funding of Developments	Poor extension support in almost every country
Improvements in rainfed agriculture	Limited access to improved seeds and inputs	Performance of the large scale and public managed irrigation schemes	Management, Operation and Maintenance	Enabling environment	More practical emphasis to support I&D and RWH
Growing population pressure	Importance of Livestock in farming systems	**Water Harvesting**	WUAs	Water Charges/fees:	Insufficient Extension Services
Expansion of support to arid or semi arid areas	Livestock Productivity Constrained by Water Supply	Siltation	Organizational structure of indigenous irrigation schemes	Good potential for improvement of I&D not being addressed in a timely manner.	Lack of extension support for the establishment or strengthening of WUAs
Coordination of programmes	Support for management of the rangelands	Small dam construction	Guidance in irrigation operation and maintenance at local level	Public/Private Managed Irrigation	Lack of extension technical capacity in agronomy & water management.
Falling labour and land productivity	Decline in soil fertility and deterioration in physical properties	Raising profile of RWH in all Nile Basin Countries	Handing over of Systems to WUAs	**Marketing**	Farmers Field School (FFS) approach
Dependence of the agricultural sector	Lack of water sources and pastures for livestock	Integrated Catchment Management	Inadequate farmer participation	Changing needs towards export markets	Poor yields, low productivity and low water use efficiency
Water Resources & Availability	Degradation of grazing lands	Emphasis on development of runoff water harvesting	Asset Management	Marketing of crops	Extension/Support Services to irrigated areas
Insufficient water to meet demands	Absence of clear legislation and enforcement to protect range lands	Full range of technologies available		Poor market facilities for Fisheries	Research system linkages to the farmer.
Early warning systems	Desertification	Spate Irrigation		High marketing margins on agricultural produce	Training and supporting incentives for extension staff
Increasing levels of pollution	Soil Fertility	Insufficient adoption of rainwater harvesting techniques and uptake of technologies		Availability of Market Information	No effective grassroots/village-based, commercially oriented institutions
Declining quality of groundwater	Policies and legislation				
Introduction of River Basin Management	Planning, Design and Construction, Implementation	Wells		Restricted access to markets	Role of Irrigation and the Development of irrigated agriculture
More information on quality/extent of groundwater resources	Production of suitably detailed I&D design documents				Loss of crops to disease and pests
	Engagement of multi-disciplinary teams				Barriers to access and utilisation
					Limited technical support for RWH
					Lack of information, knowledge and skills
					Facilitation teams

6.1 Future Directions and Possible Investment Priorities

Eighty percent of the upper Nile Basin's poor live in the rural areas and depend largely on agriculture for their livelihoods. Agricultural growth is thus a key to poverty reduction – and there is a wealth of literature to suggest that it can also help drive national economic growth. Yet agriculture in the region remains a largely subsistence activity: production has not kept pace with population growth, the numbers of malnourished people are consequently rising and food self-sufficiency has declined without the household income being generated to afford bought in food. Food and cereal crops production will need to expand rapidly in the coming years not only to keep pace with population growth, but also to make inroads into poverty. Irrigation and water harvesting is a key in this process and also a means of reducing imports.

In thee past, ad lack of clear understanding of the issues that link agricultural water development to poverty reduction and growth has been one of the reasons for underdevelopment of the sub-sector. Insufficient investments, inadequate involvement of farmers and support to them and ineffective central state management has resulted in poor performance of many traditional and state irrigation schemes. These are characterized by low crop production (similar to rainfed lands), limited water use efficiency (10-15%) and poor irrigation infrastructure. There are no quick fixes or impacts. For successful interventions, a longer term commitment and better understanding by the donor community is needed to overcome the constraints facing farmers living in marginal areas. Insufficient experienced technical professionals are involved in the decision making. Water sector strategies have not addressed the constraints experienced by both irrigated and rainfed farmers (Table 7.2). By highlighting them as has been done in this report, it is hoped that more attention will be given to overcoming some of the root causes. Extension and marketing are the over riding constraints that emerge. Poverty reduction strategies are based on agricultural growth, but agricultural water development has not been seen as a vehicle for achieving this and in fact, because of poor past performance and many preconceived ideas within the donor communities, it has been purposely excluded. Consequently it has had limited attention in such strategies.

Investment in agricultural water can contribute to agricultural growth and reduce poverty directly by: (a) permitting intensification and diversification on already developed land and raise farm outputs and incomes; (b) increasing farm employment and discourage migration to urban centres in search of better wages; and (c) increasing availability of food on local markets thereby reducing local food prices and improving real net incomes. Public irrigation development in the Nile Basin countries has been excessively costly in the past with few schemes realising the predicted returns and true potential. Irrigated agriculture in the Upper Nile Basin continues to be characterized by low productivity and hence low profitability. As many of the capital costs are now sunk, attention must be given to making these systems perform and also to introduce complimentary rainwater water harvesting into the rainfed and arid areas. Although low productivity is correlated with unreliable water supplies, low input use and difficulty in accessing profitable output markets; it is reflected by the lack of incentives for change by most subsistence farmers. Expansion into new areas to increase production has not been a successful strategy and needs to take a second place while all countries get their irrigation systems in order. A mix of interventions is likely to be required such as the improvement of existing irrigated areas, integrated watershed management (including the full range of water harvesting techniques and measures) and improved in-field water management and crop husbandry.

Table 7.2 Summary of Constraints to Agriculture and Water Use in Nile Basin countries

Constraint	Details

Increases of urbanization	Has a significant impact on available agricultural area and interferes with the upgrading and improvement of I&D systems thereby increasing costs and times for implementation of changes and reforms
Declining landholding sizes	Declining landholding sizes due to population growth and deteriorating soil fertility are among the biggest challenges facing the agricultural production system in the highland (FAO, 2005).
Improvements in rainfed agriculture	Improvements in rainfed agriculture will fail to make up the deficits and keep pace with the increasing demands resulting from population growth. If the country is to address its serious problems of poverty and food deficits, it must increase the extent of irrigation development and most importantly the productivity of existing irrigation systems.
Growing population pressure	Growing population pressure in the highland areas of rainfed agriculture on a rapidly declining natural resource base has secured irrigated agriculture a prominent position on the country's development agenda.
Expansion of support to arid or semi arid areas	Kenya's medium to high potential areas constitutes only 17 % of the total area, with rainfall of at least 700 mm per annum. The rest of the land mass is classified as arid or semi arid. This area requires irrigation for economical farming to be realized.
Coordination of programmes	Lack of coordination of programmes - Need to define more clearly the role of Donor Agencies and NGOs in the irrigation sub-sector
Falling labour and land productivity	The major constraint facing the agriculture sector is falling labour and land productivity due to application of poor technology, dependence on unreliable and irregular weather conditions. Both crops and livestock are adversely affected by periodical droughts.
Dependence of the agricultural sector	Although Tanzania is not considered a food-deficit country and normally produces over 90% of food requirements of the population, the dependence of the agricultural sector on rain means that access to food is a major concern among many households in ARAL of the centre and north.

Where water supplies have been reliable, with good access/links to markets and a conducive institutional environment, productivity has proved. Providing irrigation water alone will not guarantee increased productivity as any support provided must include a package of complimentary support that overcomes the wide variety of constraints that both irrigation and rainfed farmers experience. This needs to provide incentives for change such as improved access to inputs, reasonable returns and access/entry into adequate markets. Not all communities have access to irrigation, but many can reduce the risks that they face due to the vagaries of climate by utilising technologies for in-field rainwater management for dryland crops. These will increase the effectiveness of rainfall and, coupled with structural storage of runoff to meet other needs of their farming systems, will permit additional income generating activities. Changes in approach in projects in Tanzania whereby farmers are involved from the initial planning to implementation stage using District Facilitation Teams, have produced good improvements to traditional irrigation schemes with higher crop production, improved water use efficiency, improved infrastructure (permanent weirs and distribution network) and formal registered farmers organisations with legal status. Through these projects, successful methodologies have been developed providing greater support at District level and integration with Government irrigation services.

Such approaches are constrained in many of the upper Nile Basin countries due to poor data/information on the location and status of most existing irrigation schemes. These need to be readily available to form the basis for identifying projects for rehabilitation, modernisation and upgrading. The initiatives being undertaken on the Large Scale Irrigation Assignment that is running parallel to this assignment under EWUAP will play a significant role in this respect. Once methodologies and approaches have been completed for the larger scale irrigations schemes, they could be equally applied to small scale irrigation. Using the remote sensing techniques, it will be possible to provide useful planning and prioritisation information for many of the sites that have poor access to enable government to identify those areas with relatively low cost potential and where higher productivity improvements can be achieved.

Watershed management has an important cross boundary role in the Nile Basin if it reduces sedimentation, flash flooding and stabilises base flows. While evaluations have shown that upland communities have benefited to some degree from watershed management interventions the far greater benefits have been to downstream users. Benefits accruing to the poorer communities in the upper watersheds have been slow to materialise and have been relatively small in relation to labour inputs. In practice, some of the expected benefits may materialize only in the long term beyond any project life and this often results in a failure to compete the activities after support funds have been turned off giving smaller and sometimes negative impacts. Overall, watershed management interventions are complex and costly, and sustainability depends on continuing incentives to conservation, which can be difficult unless the investments made quickly generate sufficient revenue to motivate farmers.

Water harvesting is a key in improving the productivity on traditional rainfed lands, but some view the performance poorly. There has been an increase interest in lower cost alternatives to irrigation but it is important to be clear on the roles of each types of technology. i.e. water harvesting, which involves the collection and use of run-off, and *in situ* rainwater management, which involves reducing run-off by improving the infiltration of rainwater where it falls, storage in the soil profile and increased uptake by crops. Conservation farming and in-situ water harvesting techniques have both produced promising results depending upon climatic zone. Adoption by smallholders has been generally poor, except where it has been possible to establish market linkages. Many so called "successful" interventions have been donor driven and once the project support is withdrawn, the benefits collapse. This results from insufficient true commitment (involvement) from the farmers, and sophisticated approaches that are beyond the realistic capacity of communities. As a result, the farming systems and farmers understanding of risks and investment returns needs to be taken into consideration. External factors play an important part in this process and can be very difficult to overcome at the project level. For example the poor productivity on the large investments by IFAD into small scale irrigation schemes in Ethiopia has been partly attributed to sector-wide constraints due to poor support services, inadequate district infrastructure, poor enabling environment and insufficient access to input/output markets.

Experience in Ethiopia and elsewhere has shown promising results for integrated watershed interventions using both *in situ* rainwater management for upgrading rainfed cropping, and structural techniques for drinking water supplies (Livestock and humans) and backyard crop production. The rationale for investment in managing rainwater *in situ* is sound, but this improved rainfed cropping must go together with and not be considered as an alternative to irrigation development. Adoption in the Nile Basin has generally been poor (Table 7.5) and research/dissemination efforts have failed to address the underlying reasons which are likely to be related to availability of credit and inputs as well as access to markets. Supplementary irrigation through structural techniques has proved unviable due to the cost of storage and the losses associated with the conveyance of small amounts of water over relatively large areas.

RWH has shown good potential in areas with less reliable rainfall and where traditional runoff water harvesting techniques have been utilised with demand led approaches. Although these places still suffer in years with low rainfall amounts, they benefit in years when distribution is erratic. Yields achieved are about 10% lower than those under improved traditional irrigation schemes (4.5 t/ha) with similar water use efficiencies (20 - 30%) and they have lower investments in infrastructure, but higher risk of failure. A range of farmers organisations have derived under these new approaches, but most comprise registered associations, cooperatives or unregistered committees.

The major farming systems of the Nile Basin correspond with the main agro-ecological zones with the most rural populations engaged in agriculture occupying the higher potential sub-humid and humid zones. The trend in voluntary movement of farmers to arid and semi-arid zones due to high land pressures needs to be supported so that farmers who make this change can be equipped with appropriate but different technologies. In this respect, conservation agriculture and water harvesting become even more important. Although agricultural water development in these places is often more costly and markets more remote where land, water and markets often combine favourably so that agricultural water development in the drier areas can be more successful than elsewhere.

Institutional constraints include inadequate legal frameworks for land, water and farmers' organizations, conflicting approaches of public agencies for investment and management and the lack of empowerment of farmers to manage their water resources and to access effective agricultural support services, finance and markets. Without reforms, productivity and farm level profitability will continue to be constrained. The role played by women in most production systems must be recognised when addressing these issues with approaches specifically targeting them and encouraging their participation. This has been found to enhance productivity and poverty reduction impacts.

6.2 Returns to Investments and Benefits

As a backlash from the period of high investments in state farms and relatively sophisticated technology, donors and governments advocated the concept of "low-cost technology" for irrigation development. Interpretation has varied and is often confused with low capital investment cost per hectare that results in higher and more frequent recurrent expenditure. The initial affordability of this approach impacts negatively on sustainability, as the latter costs have to be met by farmers. The key is to examine the initial investments in relation to the skills, education and resources of the target groups. In many cases, a project will result in higher performance if initial designs and investments are made considering realistic levels of farmer managed O, M & R.

Table 7.3 Summary of Finance and Funding Constraints

Constraint	Details
Development costs	The most cost effective means of developing irrigation is through rehabilitation and upgrading of existing developments. To achieve this, more detailed information is needed on the currently developed 200,000 ha of SSI.
Funding of Developments	Insufficient funding and support for irrigation – Need to sensitise policy-makers and stakeholders on the importance and role of irrigation.
Enabling environment	In order to create an enabling environment to encourage, promote private sector and community investment in the irrigation and water harvesting sector, governments need to consider tax holidays for suppliers of irrigation services, equipment and materials and a revision of energy & water tariffs for irrigation/water harvesting. This should be coupled with development, promotion and utilization of appropriate low-cost and efficient irrigation and water harvesting technologies.
Good potential for improvement of I&D not being addressed in a timely manner.	Low investment in the sector by both government and private sector - Under the SWAP approaches, many areas with good potential for improvement of irrigation are not being addressed in a timely manner.
Water Charges/fees:	Conflicts between upstream and downstream water users are increasing in many parts of the country. New diversions or pumps are being installed upstream of existing diversion weirs resulting in water shortage for existing CMI schemes. Such cases are being taken to court and other authorities, but as there are no legal rights to water it appears there would be no immediate solution.
	Insufficient thought seems to have been given to the ability of farmers to pay for water charges at the same rate as potable water supplies and the results if the most vulnerable farmers cease to irrigate.
Public/Private Managed Irrigation	This approach seems to be successful, but is unique to the Egyptian systems due to the concepts of the original designs

Existing projects have shown that a range of viable smallholder production systems exist considering current market conditions (prices; transport; input costs; roads) and potential for import substitution. Under the concept of users pay for the resources that they utilise, incentives for change have to be given to farmers and private investors who provide capital, management, equipment and support services. Initial investments must provide clear increases in returns that not only increase significantly over current farmer returns, but also enable them to meet the increased burden of water right charges and O & M costs. The key to all assessments is the establishment of market linkages prior to investments. Demands will vary across the Nile Basin countries but will be determined by accessibility and market demanded price. The past failure to respond to market-led developments has contributed significantly to the poor performance of many irrigation schemes. Irrigated crops that give good returns are paddy, maize, vegetables, and flowers for urban and export markets. Rice has an assured market but is a high consumer of water and labour when compared with other crops such as green maize, vegetables and spices that give much greater returns per unit of water and per labour-day. When the higher yields received under improved irrigation and water harvesting are translated into crop budgets and farm models, significant increases in net returns and returns to family labour derive in all cases. In general, incremental returns of 20%-25% are achieved that compare favourably with the existing lending rates in the order of 18%-20%. These returns for improved farmer management are also sufficient to enable investments to be made in items such pumps and agricultural equipment.

Rationale for investment in rainwater harvesting and small scale irrigation development is thus sound and should have good potential in terms of improved productivity, contribution to food production and poverty alleviation. This is provided that interventions aim to address the constraints faced by the farmers and that support is tailored to address all problems faced. Profitable technologies have been identified but what remains is how to invest in the supporting activities to ensure that the specific barriers to their adoption are removed with farmers willing to invest their time and effort to compliment external investments. If each country concentrated on identifying the constraints to improved productivity on 10% of the already equipped irrigated area in their country using this knowledge to bring back into production the land that is currently unused, progress would be made on addressing the imbalance between crop production and population growth. The impacts that can be achieved are:

(i) Poverty reduction: Production of both food and cash crops under irrigated agriculture assures greater income in rural areas. Although this benefits relatively few numbers of rural farmers, it will generate income in the surrounding villages and provide competitive opportunities for casual labour. Where perennial or seasonal irrigation is not possible, backyard rainwater harvesting can benefit households especially in areas with erratic rainfall (<800 mm/an.) through the cultivation of High Value Horticulture (HVH) on 0.1 ha around the homestead. Through the sale of about 75% of this produce, families can purchase 60% of their annual family staple food needs. This is in addition to any rainfed crop production.

(ii) Food Production: Smallholder irrigation developments provide an important source of food crops with annual production being at least 4-6 times rainfed production. Excess production is sold in local and regional markets increasing availability and generating income in villages and Districts. Beneficiaries will thus move from food deficits to surplus and through this be able to meet school fees, medical expenses and clothing, re-roofing and improvement of their houses and the purchase of luxuries such as bicycles and power tillers.

(iii) Commercial Production: Irrigation provides opportunities towards commercialisation of both smallholder and medium-scale agriculture. Vegetable production, spices and flower cultivation, such as already exists in Arusha and Kilimanjaro regions of Tanzania and Ziway in Ethiopia have all shown potential. No comprehensive studies have yet been undertaken to assess the basin's potential on either local or international markets, but results in Kenya and Tanzania indicate a comparative advantage in all major food and export crops. This indicates the competitiveness of local production and the market potential.

6.3 Addressing Constraints to Improved Productivity and Efficient Water Use

The main issues arising from the examination of constraints (Part II) are examined below. With the rate of increase of population and the threat of urbanisation, it is important to establish a process that enables productivity on existing rainfed and irrigated lands to be increased and at the same time integrates interventions and resources to both rainfed and irrigated lands. Existing strategies need to be adjusted so that importance of irrigation and water harvesting in poverty reduction, crop production for the local market and crop production for national markets and export is recognised and supported. Loss of land to urban spread is a problem throughout the basin and member countries need to establish realistic physical plans that ensure that more fertile and productive agricultural land is not lost top the urban sprawl. Although the majority of population resides in the more humid and productive areas of the riparian countries, there is increased migration to the semi arid and arid areas due excessive population pressures and sub division of lands into uneconomic units. Measures must be taken to ensure that support is provide not only to the higher potential areas where most of the population lives but also increase support to arid and semiarid areas where the overflow population from the more dense areas is migrating.

All Nile Basin countries recognise the increased impact that the changes in rainfall patterns and climate are having on production. It is agreed that it is important to reduce the dependence of agriculture upon the vagaries of rainfall and this can only be done by ensuring that commitment to irrigation and water harvesting developments.

6.3.1 Establishment of Enabling Environment

Many organizations including public, private and community-based organizations are involved in irrigation and water harvesting development. There is a need to establish mechanisms for the sharing and involvement at all levels and to create channels for information sharing through enhanced networking to create synergies for improved irrigation and water harvesting development. In the case of water harvesting, national and regional groups are already established. These need to be recognised more by governments and there is a need to establish a Nile Basin Water Harvesting Network. Similar organisations are needed at national, regional and basin level for the sharing of irrigation and drainage experiences. Sections of the International Commission on Irrigation and Drainage exist in most countries, but these do not link closely enough with other national irrigation organisations and farmers representation. Partnerships need to be made with the private sector financiers, equipment suppliers, management organisations, service providers and consultants in irrigation development and water harvesting with possible incentives such as tax breaks to encourage wider involvement and suitable competition.

The establishment of an enabling environment means that suitable enabling laws must be in place relating to irrigation policy, enabling environment for water users associations and accompanying irrigation acts. Through linking with the other projects of the Nile Basin Initiative, it is possible to examine the status and statutes in other countries and the problems that were faced when developing them. Details of this information need to be readily available on the NBI websites for all users together with the supporting documentation. It is essential that these are all independently reviewed by an experienced international institutional expert to provide guidelines for those countries that have yet to complete the appropriate legislation and also to learn from past experiences of those countries with more advanced legislation.

6.3.2 Improved and Integrated Water Resources Management (IWRM)

The importance of agricultural water use in the rural economy needs to be recognized in the context of rural economic growth and development. With the competing water demands for domestic and industrial use, integrated management is essential to ensure availability of water for all growing sectors of the economy and to protect the natural environment. The management of all water sources (surface and groundwater) is needed with the interactions between water and land and the ecosystems understood and included in all development plans. Over the last two decades, noticeable changes in the availability of water sources have been experienced particularly in sub-Sahara African countries. With increasing water scarcity and much higher variability in rainfall events, changes to water management have been necessary. Although past interventions have established water needs, opportunities for land development for the less advantaged members of society who previously did not have equal access to water and related services need to be recognized and provided for. Assistance towards improving water use efficiency on existing developments will ensure that more water is available in a given basin at a given time. In many parts of the upper Nile catchment, losses within the system of irrigation and drainage networks are not total losses as they become available either downstream or through groundwater recharge. The problem faced is that at the peak demand times less water is actually available in the river systems to meet the immediate crop water needs. In addition, water quality does decline with over application that results in yield reductions due to waterlogging and salinity.

IWRM approach is essential to sustain benefits of agricultural productivity and ensure appropriate institutional mechanisms for implementation of RWH or irrigation and drainage improvements. Experience within the Nile basin has shown that many good examples of improved and integrated water management approaches exist. These now need to be institutionalised with experiences widely disseminated throughout the Riparian countries. The work that is being undertaken on Best Practices under EWUAP will lead into this process that should encourage the promotion of integrated watershed management activities within member countries (WH; SSI; SWC; environmental protection;) using examples such as the Lare experience in Kenya and the work carried out by MOA/WFP in Ethiopia.

Support for this IWRM approach has already been started under the first Subsidiary Action Program (SAP) projects in Ethiopia. This has started the process of developing follow-up projects to utilise experiences gained and linking with proposals from this study for improvement of small-scale and community irrigation and water harvesting. Support to improvement of extension services to equip them with tools and “menus” of possible interventions will ensure that a full range of proposals are available for consideration by the benefiting communities. Past experience has shown that care needs to be taken when considering investments in watershed projects for the Nile Basin countries so investment funds are not spread too thinly and that manageable units are identified. As a starting point watersheds need to be broken down into different components such as forest and upper catchment cover, farmlands of rainfed and arable lands, non-arable lands, rainwater harvesting and settlement areas and irrigation system areas - both gravity and pumped. This would link with the approach being adopted for the large-scale irrigation systems by using freely available satellite imagery for overall planning instead of purchasing spot imagery and high cost for the whole catchment.

6.3.3 Irrigation and Drainage Developments

Small-scale and community managed irrigation systems offer considerable scope for improvement of both food production at household level as well as contributing to district, regional and national food production. A number of interventions aimed at overcoming constraints (Table 7.4) and at improving the existing infrastructure will be needed together with reinforcing WUAs managing the systems (see above), introducing more efficient water service delivery (conveyance of irrigation water; establishment of measurement structures on each scheme; handing over some responsibilities to WUAs) and improving on-farm water management (productivity; water use efficiency;) with much of the O&M of the systems being undertaken an financed by WUAs. This will need to be coupled with improved and appropriate extension support (see section 6.3.11 below) provided by the state, private sector or from within the local community using the Farmer field school approach. Any interventions will need to be integrated more into the sub catchment areas in which they are located to encourage protection of surrounding areas to address issues of erosion, sedimentation and degradation.

Table 7.4 Summary of Irrigation and Drainage Systems Constraints

Constraint	Details
I & D Developments	Insufficient information is available on performance and details of existing small and medium scale irrigation developments. Priorities for support based on the potential for increasing productivity need to be established. There is a strong need to clearly establish the needs for irrigation and drainage and the process by which it can be realised. This needs to go hand in hand with the training of technical staff to support any proposed interventions.
	Many policy documents outline irrigation as a key intervention for food security and income generation - Food Policy Papers; Poverty Reduction Strategy Papers; Rural Development Strategies; Country Assistance Strategies; etc. but without providing effective support, funding and realistic implementation modalities.
	Some work has started on the water for production in the Nile Basin countries, but this is not well understood and has still a long way to go. The approaches need to be introduced into irrigation policy/acts with supporting training, research and other support to ensure information is collected and acted upon.
Condition of Irrigation & Drainage systems	The condition of many I&D systems is poor and results from inadequate past funding and a lack of beneficiary involvement in the O&M of the systems. Many farmers still believe that Government will provide all. There is a need for more emphasis on formation of users associations, local community advisers and extension services. Wider upscaling of formation of WUAs and transfer of parts of the system to them.
	The accumulation of deferred works means that expenditure can only be planned on an annual basis at the moment and that a large backlog of outstanding maintenance has accumulated. No provisions can thus be made for replacement of key structures and facilities such as gates should they fail or suffer severe damage.
Performance of the large scale and public managed irrigation schemes	Performance of the large scale and public managed irrigation schemes has been very low. These offer the greatest possibilities for improved productivity and for meeting food demands within the basin. Expert advice on improvements and possibilities must be provided to the Regional Governments who generally lack sufficient experience in managing the transfer process and improvements for such systems.

With the proposed emphasis on rehabilitation and upgrading of existing systems, consideration will be needed for the following:

(m) **Establishment of Priorities for Support:** An inventory of all existing schemes (location; information known on the systems; etc.) within the Nile Basin in each country is needed to establish the condition of systems (local data and information; satellite data; project reports; benchmarking;) and to determine priorities for support based on identified needs for rehabilitation and upgrading (using data from the current RWH/CMI studies and adopting the LSI approach and methodology). This should cover all levels and aspects for improvement including:

- Main canal system;
- Branch canal (secondary) and (tertiary) system,
- Quaternary and farm level irrigation system;
- Open and subsurface drainage network;
- Engineering studies, designs, construction supervision;
- MOM arrangements;
- Community involvement;
- Catchment management.

(b) **Comprehensive reference list on cost of interventions:** Cost and development data for all countries within the Nile basin should be collected to provide a comprehensive basis for assessment of small scale irrigation, small storage dams and water harvesting techniques to establish relevant benchmarking criteria (costs per ha or volume of stored water; cost per cubic metre of water used for production;). These can then be utilised to influence the choice of alternatives, target areas for intervention, locations with improved prospects of success; type of technologies to be used and methodologies for implementation. Once a system has been developed for collecting and compiling the data, this can be regularly updated to reflect the dynamic changes across the Basin.

(c) **Equipping of Beneficiaries:** For future sustainability, water users need to be well organized to substantially increase their participation in, contributions to and responsibilities for, irrigation and drainage systems O&M. Improved management is expected to lead to increased efficiency and more sustainable use of land and water, and to have positive impacts on water distribution, quantity, quality, equity and timeliness. This will be affected through the establishment of approaches and training for reduced and more rational use of irrigation water, at both off-farm and on-farm levels, greater and more effective participation by users and stakeholders in water management and the development and application of an integrated approach to planning, implementation and management of irrigation and drainage improvements.

(d) **Improve implementation arrangements**: Implementation arrangements should be geared solely to achieving maximum development impact for target group households, in terms of production and incomes, whilst minimizing negative externalities. Engineering designs should be cost-effective and of the highest quality with the objective of providing agricultural users with reliable water supplies. Mechanisms for subproject screening, appraisal and approval should be designed to avoid non-viable investments. Clearly defined objectives, roles, and responsibilities for those involved need to be established. Implementation service providers should be obtained from the most competent and cost-effective sources, considering local contracting capacity and the respective strengths, weaknesses and accountability of public, private and NGO sectors. Deliverables need to be clearly defined and include exit strategies.

6.3.4 Water Pricing

Research into water pricing over the last decade has shown that large increases in the price of water are not effective in improving water use efficiency. This approach tends to drive farmers out of irrigation rather than reducing the amount of water that they use. What has been effective in improving water use efficiency has been the introduction of water scarcity. This means that sufficient water is provided at the intake to a system, based on estimated field level demands considering an achievable level of efficiency in conveying the water within the system to the field and in the application of water the crop. Changes cannot be made overnight and any introduction of water pricing or volumetric restriction must be introduced in tandem with improvements to the irrigation conveyance network, the management of water within the system and the training of water users in scheduling and application of water to meet crop water needs. At WUA level, users will contribute to the cost of water with the volume of water delivered at the outflow from the secondary canal being translated into equivalents based on area and crop by the WUA committees.

6.3.5 Water Harvesting

Significantly increased support for rainwater harvesting is proposed for the Nile basin catchment (section 6.1) to overcome constraints (Table 7.5) and to encourage upscaling. Government and donors need to be convinced/encouraged to finance RWH and conservation across the full range of suitable environments in the Nile Basin catchments to develop a full range of rainwater harvesting technologies in the Sub basins to improve water retention in the already cropped areas. A series of measures will be needed to catalogue past successful interventions to encourage politicians and decision makers to understand what is needed for successful upscaling of technologies. Issues that will need to be included are:

(a) **Improving Profile of Water Harvesting within member countries and the Basin**: This can be achieved through (i) cataloguing best practice experiences and successes; (ii) preparation of a series of manuals and guidelines for use within riparian countries presenting techniques derived from existing manuals and practical experiences; (iii) matching of best practices more closely to agro ecological zones so that technologies are more closely related to agricultural regions throughout the Basin; and (iv) dissemination widely of the techniques available and the conditions under which they will be successful. This will utilise the work started on Best Practices under EWUAP and to be developed and expanded in Phase 2.

(b) **Establish links with planners, decision makers and politicians** using information available under (a) to illustrate achievable benefits and successes and that the techniques and processes of RWH have wide application. Site visits will be organised in all riparian countries to enable this target group to see for themselves and to talk with the beneficiaries. This needs to be followed up awareness activities to ensure that water harvesting is included in all national water legislation frameworks and through this process is put high on the agendas of all governments and donors.

(c) **Training of staff**: Development of manuals for professional staff, technicians and field level extension workers. This will include the establishment of processes for the adaptation of standard training materials and manuals for the training of staff at all levels in the technologies and applications and to facilitate planning and implementation.

(d) **Facilitate the construction of small dams and storage facilities** through the preparation of appropriate manuals for the design and training of staff (as above). This will include small dams and ponds to ensure that they are approached more technically with catchment areas related to storage sizes, for example, and that measures are introduce to reduce sedimentation.

(e) **Encourage integrated catchment approach** with construction of small dams and ponds associated with catchment conservation works to reduce sediment transport and catchment erosion.

(f) **Include water harvesting approaches in extension training** and curricula of universities to bring it to the front of national agendas on water resources management with adequate institutional support to ensure that interventions are not sidelined and that responsibilities are clearly defined.

(g) **Encourage adoption of water harvesting techniques** for improving and conserving water and the adoption of rainwater harvesting for domestic drinking water in rural areas and for backyard crop cultivation from storage. This can be achieved through provision of suitable material and training for extension staff and schools so that farmers and their offspring are informed of the full range of options available and the conditions under which they have proved successful.

(h) **Provide more comprehensive material on the use Spate irrigation** for the improvement of seasonal pastures and cultivation of crops. Sudan has considerable experience in this aspect and information and data should be gathered on traditional uses to supplement the new FAO guidelines. This will be combined with procedures for establishing suitable watering points for livestock and maintenance by pastoral users learning from past experiences and failures.

(i) **Identification of potential for WH & SSI** for main catchments in each country in collaboration with findings from LSI Consultancy and SVP Environment project to define areas with potential and to assess resources, fix safe levels of development, define types of interventions, develop catchment plans, and define stakeholders.

6.3.6 Water for Production

Most Upper Nile Basin countries are well endowed with water resources, mainly surface but also groundwater. Although most countries receive sufficient water for agricultural production in terms of annual amounts, recent rainfall has been erratic and unreliable in terms of onset prediction, duration and variability. Past efforts to mitigate drought have been handled on an ad-hoc basis waiting for drought to strike and then mobilising sufficient resources to establish irrigation and water harvesting developments. As these take time to implement, such an approach is often coupled with emergency food provision to prevent starvation and hardship. Experience from the Nile Basin countries suggests that irrigation (both supplementary and full), especially when considered in terms of the national economic and disaster preparedness, provides the security in food that is currently lacking. Irrigation may appear an expensive venture, but it needs to be considered in the long-term as an investment in infrastructure that needs to be properly managed, operated and maintained as an asset. If it is treated as such, it will facilitate increased and more reliable production of high value crops with ready markets. One way for increasing agricultural production in the Nile Basin is to increase the options and opportunities for subsistence farmers to take up irrigation, using localised low cost water harvesting technologies. The challenge to the NBI, therefore, is how best to put to optimal use the available water resources to increase production and productivity in crop, livestock, fisheries and forestry sectors all year round. This could be handled through building capacity to develop water resources to avail water for production on a sustainable basis throughout the year. For most commodities, use of simple water harvesting equipment, improved rain water management and effective use of timely and accurate early warning systems are key to the strategy for optimum use of the water resources.

Table 7.5 Summary of Water Harvesting Constraints

Constraint	Details
Siltation	Siltation of dams needs to be considered when examining the economics of such developments.
	Sedimentation is a major problem with many dams as design data on possible accumulation rates is based on old field information and generalised formula that underestimate actual sedimentation rates. More conservative values are needed together with catchment conservation works implemented at the same time as storage and irrigation works.
Small dam construction	There is a need to approach small dam construction in a more scientific way to ensure that the construction is sustainable and that where possible structures are located off- channel if limited information are available on the hydrology.
	Construction of small dams and ponds need to be accompanied by sediment exclusion measures and catchment treatments to reduce erosion.
Raising profile of RWH in all Nile Basin Countries	It is essential that the profile of water harvesting is raised in all Nile Basin Countries so that it is included in all national water legislation frameworks and through this process is put high on the agendas of all governments and donors.
	Water harvesting needs to be brought to the front of the national agendas on water resources management with adequate institutional support to ensure that interventions are not sidelined and that responsibilities are clearly defined.
Integrated Catchment Management	SWC works are implemented in the catchment areas of only some irrigation schemes. Some local guidelines are available but no coordination of approach or requirement is established.
Emphasis on development of runoff water harvesting	Far more emphasis needs to be given to the development of runoff water harvesting for improved agricultural production and for backyard cultivation of high value crops.

Insufficient adoption of rainwater harvesting techniques and uptake of technologies	There is insufficient adoption of rainwater harvesting for domestic drinking water in rural areas and for backyard crop cultivation from storage. Most affected from the effects of scarce water are women and children who are primarily given the role of fetching water.
	Limited use has been made of RWH for improvement of vegetative cover. Water harvesting and soil treatment are needed for improvement of vegetation cover (pit planting, contour bunds, water spreading dikes, soil ripping and chiselling) as well as providing appropriate water points for livestock watering.
	Limited adoption has taken place of RWH techniques for improving and conserving water. Much more support to farmers is needed to advise on possibilities for RWH and benefits that can be achieved.
	Research/dissemination efforts have tended to ignore the underlying reasons for poor RWH uptake which are likely to be related to access to input/ output markets (there has been good adoption where market linkages have been established or where the processor or marketer has provided in-kind credit for inputs as well as a guaranteed market price.
	The high annual variability in crop production relates directly to the unreliable and variable rainfall. Need for RWH to compensate for variable rainfall.
Full range of technologies available	Information on the full range of technologies available for domestic drinking and livestock water in rural areas and for backyard crop cultivation from storage need to be available with extension staff trained and provided with appropriate information. Most affected from the effects of scarce water are women and children who are primarily given the role of fetching water.
Spate Irrigation	There is scope for learning more on use of spate flow for seasonal irrigation of pasture and crops from Sudan where this technique has been practices successfully for many years.
	Successful experiences obtained over the years in areas like Kassala in Sudan need to be applied to other parts of the Basin. Annual accumulation of silt in channels results in very high costs in O&M budget and designs must accommodate measures to reduce amounts of sediment entering headworks & main canals.
Wells	The biggest constraint is that the wells are rarely designed hence there is a potential for interference with the hydrological systems as well as soil salinization through use of untested saline water.

6.3.7 Efficient Water Use

To achieve efficient water use, major changes are needed in the approach adopted. All water users need to be licensed, water charges need to be introduced to pay for the services provided[141], and most important of all, stakeholder participation in water management must take place not only at the higher level of decision-makers, but also at a local level for all scales of development[142]. Understanding the need to pay for the costs of services provided in getting water from the source to the point of use in agricultural development is poor. Farmers consider water to be the gift of God and that licensing water and payment of river basin or scheme charges is taking away this gift and their freedom. Considerable work has already been done in persuading farmers that although what they say is true, there is a cost in service delivery and in maintaining the enabling systems, as well as ensuring equality and resolving disputes. Problems are experienced with this approach to CMI systems where farmers have received limited to no outside assistance. The only solution is to ensure that any intervention relating to licensing/water pricing is coupled with investments to improve service delivery to the farmer's field.

Table 7.6 Summary of Water Resources & Availability Constraints

Constraint	Details
Insufficient water to meet demands	There is insufficient water to meet all demands from competing users and the potential for increasing the amount of water available is limited.
Early warning systems	National efforts and regional cooperation are required to establish national and regional early warning systems, public preparedness and other disaster management measures. National action is also needed to re-establish the deteriorated natural resource base.
Increasing levels of pollution	There is increasing levels of pollution caused by overuse of fertilisers and pesticides and from the spread of urban development.

[141] Both at River Basin level (River Basin Water Charges) and at scheme level (Scheme/WUA charges).
[142] Large Scale irrigation; Medium and Small Scale Irrigation; Water Harvesting.

Declining quality of groundwater	The quality of groundwater is declining and there are excessive levels of depletion of reserves to compensate for insufficient availability of surface water sources. More information is needed on the extent of groundwater resources that extend across various Nile basin Counties and the limit of safe development.
More information on quality/extent of groundwater resources	As with Egypt, more information is needed on the quality of groundwater and the extent of groundwater resources that extend across various Nile basin Counties and the limit of safe development.
Introduction of River Basin Management	Lessons learnt from the River Basin Management Smallholder Irrigation Improvement project needs to be much more widely applied in order to improve overall water management.

Competition for water is ever increasing (Table 7.6) and as the guidance received by countries tends to put values onto the water used, transfers to higher valued industrial and urban uses from irrigated agriculture is increasingly taking place. In addition, irrigated land located near urban centres is going out for production to accommodate the migration of rural communities in search of employment and the expansion of urban sprawl. A number of challenges have to be faced as society demands more water for agricultural production. Inefficiencies within current developments need to be overcome through improvements aimed at producing more per unit of water available to agriculture. With less land available to farmers means that when addressing these inefficiencies, increased income for farmers and reduce levels of poverty must be clear target but at the same time ensuring that environmental degradation is reduced.

More efficient agricultural water use has been achieved in the USA where schemes are well constructed, well planned and involve the private sector. Farms are large enough units and the economy of scale will ensure that water charges are reasonable in relation to farm returns. In Africa where most farms are smallholder and less than five acres (2 ha.) this presents a much greater problem particularly as many schemes have been built to lower standards or by the community as simple non-technical systems. Both require rehabilitation and upgrading at the same time as WUA empowerment and before programmes relating to water use efficiency and water charging can be introduced.

It is not possible in the Nile Basin to isolate the constraints affecting agriculture in general from those affecting agricultural water used. Most riparian countries are already attempting to improve the rainfed productivity and successful interventions in this respect will assist in overcoming constraints to irrigated agriculture (Table 7.7). With the improvements suggested in this report, it will be possible for farmer groups over time to comprehend more clearly the optimal amounts of water needed for the cultivation of particular crops. However, improvements in productivity are related to quality of seeds and other inputs as well as crop husbandry. It is thus important to support not only measures to improve on-farm water management but also agronomic practices adopted for crop cultivation.

6.3.8 Improved On-Farm Water Management

Strong and functional farmer-based institutions are a pre-requisite for efficient management of irrigation. Weak water users' associations have contributed to poor performance of irrigation schemes (Table 7.8). Sustainable and profitable irrigation development requires a range of support services to farmers and their organizations; this necessitates investment in research and extension. Poor sector coordination has hampered irrigation development due to duplication of efforts and conflicts amongst stakeholders. Experience suggests that relatively minor incremental investments in on-farm water management improvements can result in substantial incremental benefits. This includes regional water and land management adaptive research programs, extensive on-farm water control and irrigated agriculture practice demonstrations and irrigation advisory and production support services (see section 6.3.11). Proper on-farm water management investments provide significant returns and items covered include (i) modernizing of quaternary canal and on-farm irrigation systems, (ii) inclusion of appropriate equipment/ technology such as the installation of low pressure pipelines, flexible hoses, gated pipes, etc., (iii) demonstrating and training of farmers in on-farm water management techniques including proper irrigation scheduling, (iv) improved irrigated agriculture practices inside farms and at tertiary/farm interface and, (v) back-up support for irrigation and production advisory support services.

Table 7.7 Summary of Agriculture Constraints

Constraint	Details
Increase in cultivated area below the rate of increase in population	Increase in cultivated area over the last five years has been encouraging but it is still lower than the rate of increase in population estimated at 10%. Improvements in the production per capita will thus require significant improvements in productivity and the way in which water is used in the systems.
Poor adoption of technical packages for production	There is poor adoption of technical packages for production and farmers have insufficient information on crop management packages (improved seeds, fertilizer, pest control, cultural practices, harvest and post-harvest) under both rain-fed and irrigation conditions; and maintenance of soil fertility essential for sustainable production.
Limited access to improved seeds and inputs	High temperature in the dry season is unsuitable for some varieties of fruit plants like grapes, peach, apple and apricot.
Importance of Livestock in farming systems	Growing importance of livestock within the Egyptian farming systems is not balanced by increasing level of advice available and availability of improved varieties of livestock.
Livestock Productivity Constrained by Water Supply	Livestock Productivity Constrained by Water Supply and also by insufficient suitable pastures throughout the year.
Support for management of the rangelands	More support is needed to improve the management of the rangelands and also to improve resources (fire lines construction, enclosures, closing/opening technique, minimizing excessive browsing and grazing, with community involvement).
Decline in soil fertility and deterioration in physical properties	There is a lack of perception of conservation and sustainability of resources in rainfed areas with government institutions concentrating on the mechanized rainfed sector to the detriment of the traditional sector (small scale). Environmental implications are a serious decline in soil fertility and deterioration in physical properties where the soil surface is vulnerable to water and wind erosion.
Lack of water sources and pastures for livestock	Lack of water sources and pastures necessitates migration of cattle herds in search of water and pasture in the dry season. This is particularly striking in Karamoja, where transhumance is associated with cattle raiding in areas to the south.
Degradation of grazing lands	In those Nile basin countries where sufficient provisions have not been made for livestock watering, degradation of grazing lands results from the annual search for water in the more arid regions of the counties as well as during the drought periods.
Absence of legislation/ enforcement to protect lands	Absence of clear legislation/enforcement to protect rangelands coupled with inadequate policies and development planning resulting in expansion of agricultural sector at expense of range & forest lands.
Desertification	Desertification is the most serious problem facing Sudan. This is causing a deterioration of land - the potential capacity of land to produce in a sustainable manner in agriculture, ranges and forests.
Soil Fertility	Any promotion for improved fertilizer use must be based on the farmers' needs, resource availability, use of organic fertilizers and affordability.
Policies and legislation	More coordination is needed between the various organisations involved in irrigation development and crop production to ensure a greater take up of ideas and new approaches. The current weak links between research and farmers or communities must be seriously addressed
Planning, Design and Construction, Implementation	An assessment conducted on 100 irrigation schemes in Oromia region in Ethiopia showed that 17% of schemes had failed, 42% performed at less than 50% of capacity and 41% performed more than 50% of capacity. Problems identified included insufficient collaboration between relevant government institutions having a stake in irrigation, agricultural extension workers insufficiently qualified and equipped for the complex extension tasks of irrigation agronomy, soil fertility management, crop protection and WUAs were insufficiently trained to manage schemes in a technically, economically and socially sustainable way. Input supply was insufficient (Annen, 2001).
Production of suitably detailed I&D design documents	Experienced personnel not available for the production of suitably detailed design documents for irrigation schemes involve the use of private sector.
Engagement of multi-disciplinary teams	The engagement of multi-disciplinary teams is not widely used and thus the appropriate skills needed when working with rural communities to define problems, identify solutions, develop and implement projects in a participatory manner are not available.

Table 7.8 Summary of Water Management and Productivity Constraints

Constraint	Details
Water management	The time and supported needed for formation of WUAs and for them to successfully take over management of part of the systems is often far greater than originally envisaged. Much work is required to move from theory to practice in the case of PIM.
	Insufficient experience of irrigators and farmers in irrigation water control and water harvesting and conservation techniques. Poor water management techniques are used by many farmers at the moment and there is a need for farmers and water utilization agencies to be advised on best practices and to become familiar with the optimum quantities of water to be used for their needs.
	Lessons learnt in neighbouring countries in the establishment and involvement of the farmers in the WUAs and their empowerment. Farmers must be involved to a much higher degree so that they regard the systems as theirs. This should be carried out at the appropriate level, so that unjustified assumptions on their ability and willingness to take over the system are not made.
	Water distribution methods should be determined, based on local conditions as well as social, technical and economic considerations and within the capacity and resources of the community to manage and maintain them. Attention needs to be given more to productivity and efficiency of water use.
Irrigation Efficiencies	Poor levels of irrigation efficiency: Low application efficiency and poor choice of irrigation methods contribute to the limited understanding of efficient water use by many users.
	High water table and low efficiency of field drains: Poor water management with excessive levels of application in some areas and inadequate levels of maintenance and reducing effectiveness of crop production improvements.
	A significant gap exists between recommended and currently applied agronomic and water management practices. Higher levels of advice are needed by all irrigation schemes and a better system of providing suitable extension services for irrigated areas is needed as to include this with rainfed extension services has not been successful.

6.3.9 Institutional Development and Capacity Building

The importance of building partnerships to support any interventions and for the exchange of ideas, especially in the approach to integration and sustainability of water resources management needs to be emphasized. This includes partnerships between development partners (major donors; organizations for financing infrastructure improvements; suppliers of equipment; organizations with experience of institutional development relating to water user organizations); government institutions; stakeholder and beneficiary organizations.

At national level, strengthening the partnership between lead government institutions in water resources and irrigation/drainage development is essential for integrating off-farm service delivery with on-farm water and land management improvements aimed at simultaneously enhancing water conservation and increasing land productivity. In addition, project mainstreaming of environmental considerations will involve further partners in the areas of environment and public health. At local level, activities aimed at securing the future sustainability of land and water management will depend on effective partnerships between project beneficiaries and WUAs and between these organizations and government institutions.

Adequate human capacity is essential for effective, accelerated and sustainable irrigation and water harvesting developments. There is need to invest in capacity building through strengthening of WUAs and building a strong professional base for the irrigation sector with links with training establishments to ensure that their output meets the changing demands of the end-users. Experience within the Nile Basin has shown a need for continual review as many training and research institutions lose touch with private and public sector demands. A number of areas would benefit from further support:

a) Finalisation of identified potential cooperating institutions in each member state within the Nile Basin to strengthen them to support improvements in irrigation, drainage and water harvesting.
b) Initiation of the review of Curricula for all prioritised cooperating institutions so that course material is matched to field/user needs and that various categories of training

institution are supported to the needs of professional staff through technicians to frontline extension and farmers.

c) Preparation of guidelines for use by member states for the establishment of practical training/ capacity building programmes for districts and communities, especially those implementing the I&D improvements and tasked with the wider dissemination of water harvesting technologies.

d) Definition of actions to be considered at grassroots level to increase greater awareness and understanding on the urgent need for efficient water use and/or improved productivity.

e) Detailed examination of the activities undertaken for strengthening and training of WUAs and collation of material available and already in use. This will be used for expanding and scaling up of support to and coverage by WUAs to facilitate the adoption of common approaches for strengthening and training of the farmers groups.

6.3.10 Community Involvement

For the effective implementation of improved water management including efficient use within the Nile Basin, priority must be given to the empowerment of water users through the formation of appropriate groups, the introduction of enabling legislation and through training and extension to increase the momentum of socio-economic transformation in irrigated agriculture. Although much is spoken about WUAs and community management, little effective facilitatory legislation exists within the member countries. Progress is being made in Egypt for example on establishing WUAs and IOs and in ensuring that legislation is appropriate to the effective functioning of these groups. In the Upper Nile countries, slower progress is being made with duplication in the approaches with many countries not realising that guidelines, training manuals and other useful tools are already available within other member and neighbouring countries.

The performance of existing irrigation schemes can be significantly and cost-effectively improved within relatively short periods through physical improvements coupled with institutional training and reforms (see Table 7.9). By applying participatory methodology, extension workers can increase their capacity for understanding farmers' needs and interests and at the same time, farmers can greatly improve their knowledge and skills in identifying, prioritising and implementing their own development priorities. Experience sharing between the various institutions and practitioners that bring together expertise and know-how is efficient and needs to be institutionalised through national, regional and basin irrigation associations.

Interventions should ultimately aim at establishing water users groups for all levels of water harvesting and irrigation activities. For this, fully established institutional arrangements for users' participation and the integration of agencies' activities in the management of irrigation and drainage service deliveries to those users are needed. Lead agencies in managing water resources development need to guide this utilizing the principles and best practices of IWRM. The beneficiaries of the systems used, either individually and/or collectively through WUAs, will be the principal partners to the lead agency. The interventions needed include:

(a) Formation and training of water users groups to take over system management.

(b) Beneficiary participation through WUAs with adequate legal basis for their empowerment to participate jointly in the management of O&M of I&D infrastructure requires careful examination with possible amendments to existing legislation (Water Resources Laws; WUA Acts; etc;).

(c) Experiences from on-going projects in all riparian countries are important and the findings and lessons must be incorporated into the formulation of institutional development design.

(d) Formation of WUAs needs to be completed initially to the point of reaching committed representative or majority agreements on association arrangements.
(e) Finalization of designs for rehabilitation and upgrading of infrastructure must proceed in parallel to enable early participatory agreements to be reached on the basic principles, plans and nature of improvements to the I&D systems that the water users will eventually need to manage.
(f) Design and execution of water management and irrigated agriculture adaptive research and field demonstration programs are also to take place and commence at this time, so as to provide water users with early perspectives on potential water and land productivity enhancements.
(g) Final formal establishment of, and institutional management training for, WUAs is effected in parallel with the detail design of improvement works and before construction tenders are issued.
(h) Initial technical water management and O&M training for WUAs to take place at the same time as construction works, prior to the handover by contractors of improved infrastructure.
(i) Programs of support for irrigation and production advisory and support services to commence in time for their full application following works construction.

Improved O&M and agricultural production activities to commence following the handover of works, supported by continuing training and field demonstration programs. The transfer of management responsibility on existing I&D schemes should be attempted only where it can be demonstrated that irrigators can sustainably bear on-going O&M costs, including any subsequent replacement costs. The implication is that not only should the costs be covered by incremental farm incomes but that there should be sufficient margin to leave irrigators with an incentive to operate and maintain the facilities. A need for empowerment and capacity-building for the users is also implied, for which adequate time should be allowed prior to transfer. Major infrastructure that is clearly beyond the capacity of the users to operate and maintain (with or without a service provider) should be managed jointly by an agency and users, or by an agency accountable to the users

Table 7.9 Summary of Management, Operation and Maintenance (MOM) Constraints

Constraint	Details
WUAs	Insufficient attention was paid to proper establishment & empowerment of WUAs who were insufficiently trained to manage schemes in a technically, economically and socially sustainable way. Their involvement has not been sufficiently participatory resulting in collapse of the WUA once project support has been removed.
	Progress with formal irrigation has been very slow and with limited success. One reason is the top-down approach adopted in most schemes. There is limited experience of water users associations in the upper Nile Basin and need beneficiary involvement from the start of any project interventions for successful formation.
	Avoid WUAs excessive expenditure on staff and other costs in relation to amounts allocated to maintenance and keeping the systems in good repair. The key aspect is to determine the desired level of maintenance expenditure to initially overcome past under investments and to maintain the systems adequately. See section 3.3.1.1.
	Review of the laws that are currently used for forming IOs is needed to adapt them to non-profit making organisations for solely managing the schemes. This will form part of the irrigation policy and must cover levels of water charges, water rights for irrigators and all related issues.
Organizational structure of indigenous irrigation schemes	The organizational structure of indigenous irrigation schemes has a vital role in the sustainability of small scale irrigation schemes with members fully participating in maintenance activities and having a firm stand against water theft and observance of unwritten byelaws and elected leaders. These attitudes are contrary to those in many Government/NGO initiated schemes.
Guidance in irrigation O&M at local level	There has been as lack of guidance in irrigation operation and maintenance at local level, either sub district or district level and farmers have relied too much on government support for maintenance tasks – many could have been handled by participating with the community at the early stage of the project

	cycle.
Handing over of Systems to WUAs	Many of the irrigation and drainage systems in the Nile Basin are in poor condition. More effort is required to ensure that effective WUAs are established and that they are trained and able to take over much of the O&M of the systems with charges levied related to the ability of the farmers to pay.
	It is not reasonable to expect WUAs to achieve the "required standard" of O&M when this has not been defined and when continued and appropriate training/support are not regularly provided as part of a structured plan.
Inadequate farmer participation	Inadequate farmer participation, focus on physical works, and insufficient clarity about the status of the systems and responsibility for management have been typical of the organizational culture of government-led small-scale irrigation development in the country.
	Users have limited past involvement in I&D system development. Before handover is carried out, beneficiaries through the WUAs need to be fully involved in planning and implementation of rehabilitation/ upgrading works so that they understand the full implications of receiving the 'completed' works that they will need to maintain.
Asset Management	The failure on the part of government to define clearly the requirements and obligations with respect to asset management will result in the 'mining' the value of the assets by communities or WUAs who, together with Govt, have failed and continue to fail to invest sufficiently in infrastructure over time, leading to system failure in the longer term.

6.3.11 Extension Support

In every Nile basin country the issue of inadequate extension services has been raised (Table 7.10). This is affecting both irrigated and rainfed agriculture. Improvement of extension support to farmers has concentrated minds across the Nile Basin for some time. In Uganda and Tanzania, some progress is being made with links established with training institutions to improve the quality of service available to farmers. Closer examination needs to be carried out across the basin to see how all these issues are being addressed. Separate extension services will be needed for rainfed and irrigated agriculture. The support to water harvesting technologies can be included in the extension support provided to irrigation schemes but developments with *in-situ* techniques fit more closely with the extension services provided to rainfed areas. Although line ministries are responsible for preparing guidelines strategies and approaches, in many Nile Basin countries, the services for planning and implementation of irrigation and water harvesting is now delegated to regional or district level authorities. At these levels, groups of specialised professionals and technicians work together in multi-disciplinary teams to support communities. Delineation of responsibilities that exists at national level will in many cases disappear but many staff lack sufficient training and experience to deal with the range of technical issues that confront them. Links with private sector consultants and experienced officers within the main line ministries becomes more important in these situations with staff requiring regular professional development as well as access to appropriate technical guidelines and reference material.

The success of irrigation productivity improvements will rest on the ability to provide the lacking extension support. With the higher returns that will accrue to irrigated agriculture, farmers will be in a better position to pay for services provided by the private sector. These do not necessary have to involve monetary payment, but could involve a share of the increased crop yield – a system used in other parts of the world to pay water masters. If the extension staff are good at their tasks, yields and hence their payments, will be high. In these cases awareness and training form a very important part of any programmes and these needs to be linked to either existing or improved extension services. The farmers feel school approach developed by FAO is proving successful under many scenarios and this should again be considered within the context of providing adequate extension services to irrigation and water harvesting developments. The scope for establishment of private advisory services needs to consider the above to overcome the past constraints whereby farmers will not pay in cash and extension service providers do not find sufficient numbers of farmers or farmers groups to make it worthwhile for them to provide the service. Issues to be included are:

a) Training and advice in irrigated horticulture that can contribute significantly to poverty reduction and has not yet reached its potential in terms of productivity and farmers income.
b) Sourcing of inputs/credit and the problems related to commercial risk.
c) More technical support to be provided to the farmers, especially the resource poor to cover the full range of crops and technical options available.
d) The linking of a research system more closely to the needs of farmers.
e) Provision of incentives and guidance for extension staff.
f) Provision of effective information systems on demand for crops and seasonal variations.
g) Development of practical guidelines for farmers with messages that are easily understood.
h) Improved support in areas of financial management and the development of crop budgets for farmers.

6.3.12 Uptake of technologies

Uptake of new technologies is achieved when it is affordable for the buyer and profitable to the producer. The technology must function reliably and the purchaser must be satisfied. It only takes a few dissatisfied customers to ruin the market for a new product. No technology can be considered appropriate for all conditions and identification of appropriate sites becomes important. The setting up of supply chains to ensure that there is sufficient manufacturing capacity of a high enough quality to meet the demand is essential. As demand usually needs to be stimulated when new technologies are introduced, opportunity exists to balance marketing activities with development of supply chains. In this way the level of expectation created among farmers can be balanced with the means of satisfying it. To be profitable a technology must have a low overall cost that does not expose the owner to debt and it make money. All machinery fails eventually and in developing countries, failure tends to occur sooner because maintenance is poor and conditions more hostile. Strong supply chains are thus needed to support the supply of spare parts and maintenance must not be underestimated. Fear of failure has often driven people towards high tech solutions to avoid the problems of breakdown.

Table 7.10 Summary of Extension Services Constraints

Constraint	Details
Inadequate extension services to support I&D and RWH developments.	In every Nile basin Country, the issue of inadequate extension services has been raised. In many cases it has been assumed that staff dealing with rainfed agriculture can also manage extension services for irrigated agriculture. This is rarely the case and requires different skills and experience. The success of irrigation productivity improvements will rest on the ability to provide the lacking extension support. With the higher returns that will accrue to irrigated agriculture, farmers are in a better position to pay for services provided by the private sector. These do not necessary have to involve monetary payment, but could involve a share of the increased crop yield – a system used in other parts of the world to pay water masters. If the extension staff are good at their tasks, yields and hence their payments will be high.
Poor extension support in almost every country	Examination of the constraints to both rainfed and irrigated agriculture highlights the poor extension support in almost every country, the lack of availability of quality seeds and other inputs, and the absence of readily available credit for small farmers to facilitate the time the purchase of inputs.
More practical emphasis to support I&D & RWH	Much more practical emphasis is needed to ensure that the message is understood by farmers and that alternatives are presented to them.
Insufficient Extension Services	Farmers need more support in areas of financial management, water management, improvement of agricultural practices and technology, accessibility to inputs and appropriate market outlets.
Lack of support for the establishment or strengthening of WUAs	The poor extension support to irrigated agriculture including the establishment or strengthening of WUAs and SWC works in catchments is a threat to the sustainability of interventions in irrigation (IFAD, 2005).

Lack of extension technical capacity in agronomy & water management.	Agricultural extension workers are insufficiently qualified and equipped for the complex extension tasks of irrigation and drainage with insufficient technical capacity in agronomy & water management, system design and improvement, irrigation agronomy and water management.
	Farmers, especially the more resource poor, need more technical support to advise on choices of crops to grow, the relative amounts of water that each crop uses and the overall profitability of the cropping patterns.
Farmers Field School (FFS) approach	Government extension support has not been widely successful and to address this, the Farmers Field School (FFS) approach was introduced in Western Kenya (Kakamega, Bungoma and Busia) continues to be used in many areas. It appears successful considering the number of extension workers and resources provided.
Poor yields, low productivity and low water use efficiency	Yields within the country are generally poor with low productivity and low water use efficiency. Extension support needs to be improved in order to realize the full potential.
Extension/Support services to irrigated areas	The Extension/Support Services to irrigated areas needs to be significantly improved to ensure that good and appropriate advice is provided and that the poorer and resource poor farmers are given better support.
Research system linkages to the farmer.	The research system is not closely linked to the farmer; extension services are not adequate and reach few farmers (Extension service reach of 5-10% of farmers; Reach to LC I areas – 16%, 33%, 9% and 45% in Central, Eastern, Northern and Western regions); rates of technology adoption is below 30%..
Barriers to access and utilisation	Barriers to access and utilisation include cost; theft; unavailability in nearby markets; poor quality; and lack of advice. Uganda National Household Survey indicates that only 1% of poor farmers use improved seeds. About one fifth of better-off farmers use improved seeds in the central, eastern and western regions.
Training and supporting incentives for extension staff	Extension staff need to be trained and provided with transport & fuel to support any irrigation and RWH interventions. Incentives and guidance will be needed to motivate staff who will need to be provided with training manuals and guidance for the farmers. It is hoped that once established, farmers will see the benefits of advice on water harvesting and this could be supported through service providers from the private sector.
Lack of information, knowledge and skills	Many communities blame the lack of productivity on the lack of information, knowledge and skills concerning better methods of food and income-generation (crop production, animal husbandry, fishing methods and alternatives), soil conservation, pest and disease control, marketing opportunities, prices, processing and pertinent government policies and regulations.
No effective grassroots/village-based, commercially oriented institutions	At present there are no effective grassroots/village-based, commercially oriented institutions capable of mobilising the production capacity of small producers for the production of income-generating commodities. The co-operative movement, which was effective in mobilising farmers in this fashion, has not been able to perform this function in the past decade.
Loss of crops to disease and pests	The loss of 35-40% of crops to disease and pests severely limits productivity of both food and cash crops – cassava, coffee, banana, tobacco, groundnuts and cowpeas. Poor farmers are unable to cope with diseases and pests because of a lack of money, limited availability of drugs and pesticides, lack of or misguided advice, conflict with Government regulations and officers.
Facilitation teams	Facilitation teams with a broad range of skills need to be established and these should link with scheme or community extension agents offering day-to-day assistance in both irrigation and RWH. They will be responsible for assisting farmers in formulating/upgrading IOs and in implementing related activities.
Limited technical support for RWH	Although in some areas of Tanzania, RWH is already widely practiced, little technical support is extended to farmers by professionals and other bodies.
Role of Irrigation and the Development of irrigated agriculture	Agriculture can contribute significantly to poverty reduction as it is the largest employer of labour, 80% of the poor are engaged in agricultural activities and studies have shown that, because of the value added and the consumption multiplier effect, agricultural growth actually accounts for 60% of the 5% growth rate in GDP.
	Government should encourage the development of irrigated agriculture, particularly by communities and the private sector, including individual farmers and ensure a conducive environment for this process, including for example negotiating with banks to extend credits for irrigation development.

There are a number of technologies available in the regional markets with many sourced from Kenya and Egypt. Once farmers are aware of the need to improve productivity and efficiency of water use, it is a suitable time for the introduction of appropriate technologies (for abstraction, conveyance, irrigation scheduling, and application/on-farm water management). Many of the technologies available on the market have not been properly tried and tested in the region and are not well supported by dealers and suppliers of spare parts. It is important that efforts are made to produce standards for such equipment and that suppliers are linked with appropriate institutions to assess the suitability and to spread awareness. Training is an important part of this process and organisations capable of leading the process of organising training and the supply of technologies need to be identified. Field support from experienced technicians is required rather than more government staff. Many farmers who would be interested in different technologies are located in the smaller and remoter rural villages. Local rural dealers will thus be needed throughout the country adopting the technology and these will be successful if they are the same who provide inputs.

6.3.13 Monitoring and evaluation of outcomes/results

Monitoring and evaluation should be regarded as an essential management tool for farmers, implementing agencies and financing partners. M&E systems are not well established in the Nile Basin Countries and this needs to be addressed. Systems should be farmer-based and designed in such a way that they can be used for both farm and project management decisions, to measure the contribution of agricultural water development to achievement of the MDGs and to inform future strategic planning and project design. As a minimum requirement, M&E systems should measure inputs, costs, and changes in production, incomes, employment, health and the environment.

The information gathered during the implementation of projects, needs to be made more widely available. Many organisations have learned useful experiences but these have not made these available to outside institutions and practitioners. A system for effective sharing of information practices needs to be established and this can be extremely useful in improving uptake of technologies as well as improving technical approaches. The regional water harvesting associations provide a good model of both formal and informal transfer of information. It should be noted that where web based systems are being used it is essential that data are regularly updated and that reports and information produced are made available promptly on these sites.

6.3.14 Market development

Sustainability of irrigation depends on the benefits that accrue from the investments. The profitability of irrigation and productive water harvesting interventions is affected by market availability necessitating development of an appropriate marketing system and strategies for marketing of irrigated produce. Insufficient attempts are made within the government and donor communities to establish market linkages prior to the commitment of investments. A number of useful projects have been undertaken by IFAD in Tanzania and experiences from these should be utilised to address the issues and constraints presented in Table 7.11.

Table 7.11 Summary of Marketing Constraints

Constraint	Details
Changing needs towards export markets	The changing needs towards export markets needs to be supported by good advice on export quality and requirements and how the farmers can achieve this
Marketing of crops	There has been oversupply at harvest time & depression of prices. Insufficient advice on planning of crops and staggering of crop planting dates has been available to farmers.
	Poor prices received by farmers as there have been poor market linkages and domination of the market by traders who dictate prices to farmers.
Poor market facilities for Fisheries	Women appear to be most affected by inadequate market facilities, such as sanitation or shelter. Although both men and women are involved in marketing, women may have limited access to the profit.
High marketing margins on agricultural produce	Major constraints to higher farm productivity and incomes are high marketing margins on agricultural produce, and inadequate allocation of budgetary resources and of the scarce foreign exchange earnings. As a result, the low input/ low-productivity model of production continues to prevail, and small farmers' incomes remain depressed.
Restricted access to markets	The restricted access to markets and market dues constrains the produce that farmers can grow. Ready markets are not available for sale of produce and purchase of inputs; long distances to produce markets, impassable roads and lack of affordable transport. High market dues for produce sales in general, relative to low incomes are said to eat into market profits.
Availability of Market Information	The availability of statistics regarding food crops and export crops is unsatisfactory with many agencies involved in the collection and dissemination of agricultural data. There is therefore an urgent need for the establishment of information services that is acceptable to producers and market operators.
Access to markets	Statistics from Uganda show that the average distance to a periodic consumer market for sale of produce is 5 km (25% of the population living within 1 km) and that it is an average of 11 km to a major market.

.7 Appendix: Country Reports

ANNEX A – BURUNDI COUNTRY OVERVIEW

Burundi

Burundi is a landlocked country that is bordered by Rwanda in the north, DRC Congo in the west, and Tanzania in the East. It covers an area of 27 834 km^2 and in 2002, the cultivated areas was approximately 1,350,000 ha, of which 986,000 ha were occupied with arable crops and the remaining 365,000 ha with perennial crops (Table A.1). The population of the country was estimated at about 7 million in 2004 of which 46% were below the age of 15. Next to Rwanda, Burundi has the second highest population density in Africa ranging from 254 persons/km^2 up to 400-500 persons/km^2. The highest growth rate was experienced in 2000 at about 3%. About 90% of the population lives in the rural areas and rely upon agriculture and livestock for their livelihood with food crops dominating. Average land holding varies from 0.7 to 0.4 ha. Poverty and vulnerability is experienced equally in the towns and the rural areas with between 35-58% living below the poverty line, but the increase is experienced most in the urban areas.

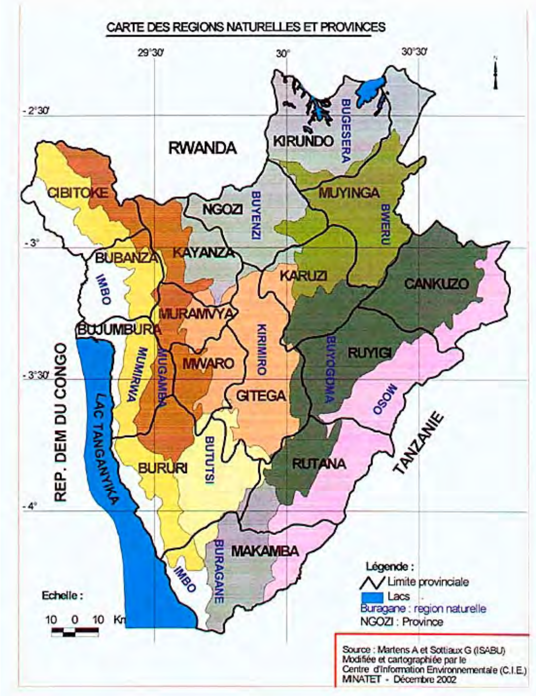


Figure 1: Provinces and natural regions

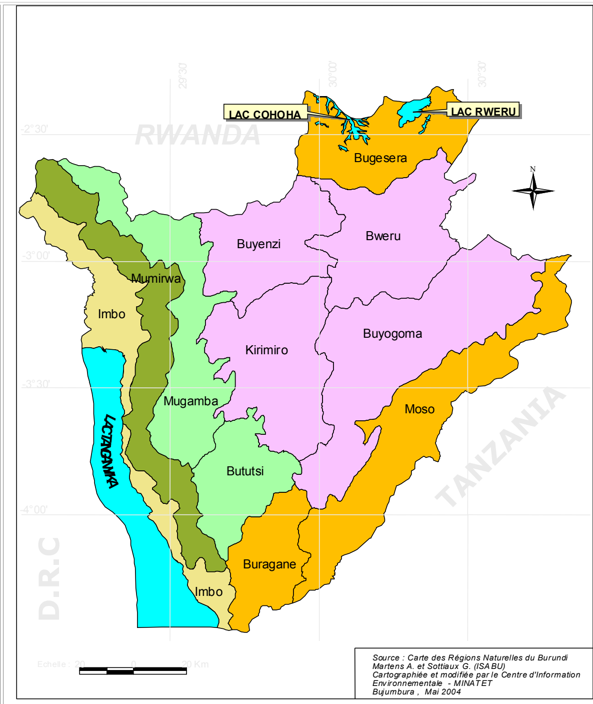


Figure 2 : Natural regions and agro-ecological zones

***Source*: Niyongabo, Dr Ir Henri. 2007**

Agriculture involves 90% of the population and contributes 49% of GDP. It is dominated by traditional agriculture practises which have been exacerbated by the turmoil in 1993 during which agriculture production declined steeply and GDP dropped by 20% between 1993 and 1998.

And the analysis of the food security over the last 11 years has shown a rapid decline in nutrition and much of the population suffering from malnutrition and food deficits. This has resulted in poor health and a rise in incidences of Cholera, dysentery, meningitis and a vulnerability to HIV/aids. Food production is relatively unstable varying from periods of access to shortages and is unable to keep pace with the rise in population. The average production per person is estimated at about 600 kg/an. with the crops grown reflecting the farmers need to minimise risk, yields are very low resulting from the degradation of the soils and poor utilisation of inputs.

Table A.1 Main Features of Burundi

Physical area			
Country area	2002	2,783,400	ha
Cultivated area (arable land and permanent crops)	2002	1,351,000	ha
In % of the total area of the country	2002	49	%
Arable land (temporal crops +grassland and land fallow (sometimes)	2002	986,000	ha
Permanent crops	2002	365,000	ha
Population			
Total population		7,068,000	Persons
- Of which rural		90	%
Population Density		254	Persons/km^2
Active population		3,739,000	Persons
- In % of the total population		53	%

- Female		49	%
- Male		51	%
Population Working in the Agricultural Sector		3,355,000	Persons
- In % of the total population		90	%
- Female		53	%
- Male		47	%
Economy and development			
Gross domestic product		669	Millions of Euro/an
Added value for the agriculture sector (% of the PIb)		49	%
PIB by habitant		95	Euro/an
Index of human development (more elevated =1)		0.339	
Access to improved clean water			
Total population		79	%
Urban population		90	%
Rural population		78	%

Source: FAO Aquastat, 2005

Burundi is one of the poorest countries in the Nile basin and suffers from widespread food insecurity. It comprises mountainous terrain with high plateau is deceptive by wide valleys in the centre and east of the country. Elevations vary from 775 m up to 2670 m and this gives 11 agro-ecological zones. Five climatic zones derive:

- The zone to the west along Lake Tanganyika that is formed by the lower plains with an altitude varying from 774-1,000m having a warm climate with an average temperature of 23°C, rainfall that varies from 800-1,000 mm/an and a dry season of 5-6 months. This occupies 7% of the country.
- The escarpments in the east towards the more mountainous areas with altitudes varying from 1,000 to 2,000 m. Rainfall varies from 1,100 to 1,800 mm with the temperature ranging from 23°C down to 17°C depending upon altitude. This occupies 10% of the country.
- The Central plateau zone with an altitude of between 1,500 and 2,000 m and an average rainfall of between 1,150 and 1,500 mm. The climate is tropical with a short dry season of 4 months (June to September) and colder temperatures that range from 16 - 18°C. This is the largest zone in the country and occupies 44%.
- The divide between the Congo-Nile river basins. Here the elevation ranges from 2,000 to 2,670 m and the zone is characterised by higher rainfall (1,500 to 2,000 mm) and a montane climate with average temperatures from 12 à 16°C. Here the dry season lasts for 3 months (June to August). The variability of the rainfall is quite high and the largest amounts fall in April and November. This is the wettest part of the country and contains the Kibira National park, natural forests and the greatest source of water. Here the evaporation is not as important as the humidity in this area is high. This zone occupies 15% of the country.
- The depressions in the east and north east. Here the altitude is between 1,320 and 1,500 m and the average annual temperatures above 20°C. The dryness of these areas is very marked and rainfall really exceeds 1,100 mm and often is as low as 600 mm. Humidity levels are lower in this zone and the dry season varies from 5-8 months. This zone covers about 24% of the country.

Generally, the country is endowed with a high density hydrologic network, notably in the central plateau where multiple flat bottomed valleys crossed by rivers are found. These are sometimes badly drained. Most annual rainfall (1,274 mm) occurs between November and April and contributes directly to the dense network of watercourses. Rainfed cultivation is possible in most places except in the lowland of Imbo, Bugesera and a part of Moso. These areas rely upon rivers whose flow derives from the surrounding highlands where rainfall is abundant.

On average, the available water resources are estimated at 319 m^3/s or 10.06 Km^3/year including both surface and groundwater resources. The discharge of the transboundary waters is around 336 m^3/s or 10.596 km^3/ year. The only river that flows into Burundi is Kaburantwa River with a discharge of 4 m^3/s or 0.126 km^3/year. The available renewable water resources in an average year (Table A.2), gives the total flow (base flow and runoff) as 319 m3/s corresponding to a depth of 402 mm or 32% of the total rainfall. Base flow contributes around 237 m^3/s or 7.47 km^3/year or 74% of the total flow. This varies between catchments from 63% to 89% depending on retention capacity that in turn depends on aquifer capacity, valley alluvium and swamps. The guaranteed flow for 95% occurrence has been estimated at 157 m^3/s or 4.95 Km^3/year, corresponding to the minimum water resources at end of the dry season. It is less than the average monthly flow for the driest month of the year (generally in September) but always greater than the minimum yearly discharge.

Table A.2 Average Water Balance for Burundi

Units	Rainfall	Evapotranspiration	Base Flow	Runoff
mm/an	1,274	872	299	103
m^3/s	1,011	692	237	82
%	100	68	23	9

***Source*: FAO Aquastat, 2005**

The country is well endowed with springs with an estimated 36,000 of which around 14,500 are derived locally. An inventory of the springs gives a total discharge of 886,000 m^3/day, which in theory, would supply water to more than 40 millions of people with an average specific consumption of 20 l/day of drinking water. Currently around 491 wells and boreholes (291 wells; 174 boreholes; 26 test boreholes) are used for drinking water supply.

The three main lakes of Burundi are all located on the border with neighbouring countries including Tanganyika, one of the world's deepest lakes (1453 m). The other two lakes of North Cohoha and Rweru are characterized by shallow depths.

In 2000, available water resource usage was estimated at 288 million m3 of which 200 millions m^3 were used for agriculture (69%), 22 millions m^3 for livestock (8%), 49 millions m^3 for domestic use (17%) and 17 millions m^3 for industry (6%) as shown in Table A.3 below.

International waters: Burundi is located in both the Congo and Nile Basin catchments. It is thus a member of the Nile Basin Initiative launched in 1999 by the council of Nile Basin water ministers (Nile-COM).

Table A.3 Water Resources and Use for Burundi

Water: Resources and Use Renewable Water Resources			
Average rainfall		1,274	mm/an
		35,460	10^9 m^2/an
Internal renewable resources		10,060	10^9 m^2/an
Total renewable water resources		12,356	10^9 m^2/an
Dependency index		19.75	%
Total renewable resources per inhabitant	2004	1,774	m^2/an
Total capacity for dams		-	10^6 m^2
Water use			
Total Water Use	2000	288	10^6 m^2/an
Irrigation and livestock	2000	222	10^6 m^2/an
Collectivity	2000	49	10^6 m^2/an
Industry	2000	17	10^6 m^2/an
Per inhabitant	2000	46	m^2/an

As % of renewable water resources	2000	2	%
Non conventional water resources			
Volume of waste water produced		-	10^6 $m^{2/}$an
Volume of waste water treated		-	10^6 $m^{2/}$an
Reuse of the waste water treated		-	10^6 $m^{2/}$an
Water desalinized produced		-	10^6 $m^{2/}$an
Reuse of waste water from the drains		-	10^6 $m^{2/}$an

Source: *FAO Aquastat, 2005*

Irrigation and Drainage Development:

According to a survey carried out in 1978-1979 by the Department of Rural Engineering, the potential irrigable land in Burundi is estimated at 215,000 ha of which 75,000 ha comprises the Imbo plains in the West and the Moso depression in the East, 20,000 ha of foot hills, and 120,000 ha of swamps[143]. The most predominant irrigation method is surface irrigation (basin; furrows; ridges) derived from river runoff. This method is best adapted to the limited experience of the population with irrigation who use simple layouts and structures with no formal infrastructure. Maintenance is not difficult and can be done locally by farmers themselves. Storage dams are not yet needed as the extentd of irrigation is limited and the periods of rice cultivation correspond with the rainy season (Jan to May). Such dam projects for irrigation are under plan for an area of 21,430 ha in the Imbo and Mosu south plains and also for the higher altitude swamps where rice is cultivated. These projects include:

- Agriculture for vegetables and coffee in North Imbo (1,300 ha);
- Rice cultivation in plains of Imbo-Centre (4,050 ha);
- Rice cultivation in Moso (160 ha);
- Sugar cane in Moso (Sosumo) (1,450 ha);
- Rice production at high altitude (14,470 ha).

Irrigation with total or partial control of water is not yet well developed (figure 2 and 3) In fact, the areas indicated are small when compared with the potential that exists. Many swamps are found at elevations from 1000 to 1700 metres. In 1990 it was estimated that almost 40% of them had been developed for traditional farming by farmers without any adequate technical guidance. By 1999, it was estimated that this percentage had reached 69 % or around 83,000 ha. Nowadays, it has changed greatly due to the extension of rice growing at high altitude. The area of marshlands managed with a regular follow up is estimated to 14,470 ha, or 12 % of the total area. The total area with water control is estimated to cover 104,430 ha (Table A.4) and the area of the marshlands to be protected has risen to 7,113 ha, representing 6 % of the total area of Burundi marshlands (120,000 ha).

Table A.4 Irrigation Situation in Burundi

Irrigation and drainage			
Potential for irrigation		215,000	ha
Control of water			
1. Total/partial control of irrigation: equipped area		6,960	ha
- Surface irrigation		6,960	ha
- Sprinkler irrigation		-	ha
- Localized irrigation		-	ha
- Irrigated part from the groundwater		-	%
- Irrigated part from the surface water		-	%
2. Low land equipped (swamps, valleys, plans area, mangroves)	2000	14,470	ha
3. Spate Irrigation by	2000	-	ha
Total area equipped for irrigation(1+2+3)	2000	21,430	ha

[143] Estimated by Department of Rural Engineering in 1984.

· In percentage of cultivated area	1985-2000	1.6	%
· Average increase per year on the last 15 years		2.7	%
· Irrigated area by pump n % of the area equipped		-	%
Area equipped really irrigated	1999	-	%
4. Swamps and valleys cultivated and non equipped		63,000	ha
5. area for agriculture in recession non equipped		-	ha
Total area with control of water(1+2+3+4)	2002	104,430	ha
In percentage of the cultivated area	2002	7.9	%
Perimeters with total/partial control		**criteria**	
Irrigation perimeters for small scale <50 ha	2000	600	ha
Irrigation perimeters of middle scale >50 ha - 100 ha	2000	500	ha
Irrigation perimeters of large scale > 100 ha	2000	5,660	ha
Total number of family in irrigation		-	%
Irrigated crops in irrigated perimeters with total /partial control			
Total production of irrigated grains	2000	25,260	tonnes
- In % of the total production of grains		10	%
Total area of irrigated of harvested crops		-	ha
Annual crops/temporally: total area for		-	ha
- Rice	2000	4,210	ha
- sugar cane	2003	1,450	ha
- Legumes.	2003	600	%
- Coffee	1997	500	ha
Permanent crops : total area		-	ha
Cropping intensity of irrigated crops		-	%
Drainage-environment			
Total area drained		-	ha
- Part of the equipped area for drained irrigation		-	ha
- Other area drained and not irrigated		-	ha
- Area drained in % of the cultivated area		-	%
Area protected against flooding		-	ha
Area salinized by irrigation		-	ha
Population affected by waterborne diseases		-	Persons

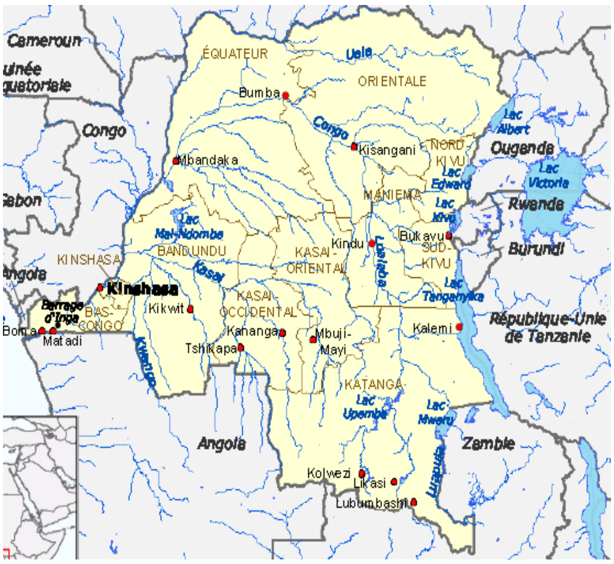
There has not been any systematic water resource analysis, except in connection with the REGIDESO water supply systems related to urban centres. River water quality is affected by erosion, mining activities, use of agriculture (fertilizers) and the development of marshlands. In general, despite erosion due to high slopes and topography and because of lack of sufficient soil conservation structures, the quality of surface water is adaptable to irrigation and to fish farming. The other factors are not so important because the mining activities not well developed and use of agricultures fertilizers remains weak. Among the diseases related to irrigation come often the malaria and the Bilharziasis. During a workshop in February 2000, water resources management in Burundi was discussed but programs and projects have still yet to be established. Irrigation water needs for 2010 have been estimated at 758 million m^3 compared with current usage of 200 millions related to an area under irrigation of 24,662 ha of which 22,221 ha are located in Imbo, 941 ha in Moso and 500 ha in Buragane.

ANNEX B – DEMOCRATIC REPUBLIC OF THE CONGO COUNTRY OVERVIEW

DRC

The Democratic Republic of Congo is situated in Central Africa on equator, and covers 2,344,860 Km^2 and after Sudan and Algeria, is the third largest country in Africa. DRC is semi enclave with a littoral of less than 100 km on Atlantic Ocean. Eleven provinces, and share its borders with 9 countries: in the north the republic of Central Africa and Sudan, in East, Uganda, Rwanda, Burundi and Republic of Tanzania in South the Angola and Zambia and in the oust the republic of Congo, and enclave of Cabinda (Angola) it has 80 millions of ha of arable land with a good potential for fertility. The vegetation is very dense and diversified .the half of the equatorial country is covered by forest (125 million ha). Near of the tropics the other half is dominated by savannah. The cultivated areas in 2002 were at around 7.8 millions of ha with 1.1 millions in permanent cultures (Table B.1)

In 2000, the water resources were estimated to be 356 millions of m^3 with 112 millions for agriculture (32%) 186 millions for the domestic use 52 % and 58 millions for the industry (16%).



The country is subdivided in 5 main agro-ecological zones:

- Vast alluvial low valley l or (cuvette) in the middle with an altitude between 300 and 500m covering the third of the territory .Its vegetation is composed by equatorial forest and swamps. It is not well occupied.

- Gradual Plateau in of savannah bordering that cuvette in the north and south (700-1200 m of altitude) and are more densely populated.

- Volcanic ridges of high altitude in the east and north east (1500 to 5000 m) (in the Kivu region) with a population density that is very important. This ridge divides the Congo and Nile basin.

- Litoral that extends from the Ocean up to Mont de Crystal.

- Katanga.

The climate is equatorial, hot and humid in the centre and progressively tropical to the south and north. The rainfall is regular and enough (1545 mm/an on average) but variable in the space and time (from 800 to 1800 mm) the rainfall allows two agriculture seasons. The main rainy season which lasts, on average, 8 months of 12 months changes with a dry season. The population was estimated in 2004 to be around 54.4 millions of inhabitants with 68 percent of farmers (table 1) and the average density is 23 inhabitants by km^2 with high disparities in the region. The annual demographic rate growth is 3.3 for %. In 2001 80 % of the population were living below the poverty line and only 4% of the active population had a job. In 2000 only 29 % of the population in rural area had access to clean water and 83 % in urban area (46 % at national scale). Life expectancy is 46 years in 2001 and the HIV prevalence rate is 4.9 % in groups between 15 and 49 years finally the secularization.

The agriculture occupies an important sector in economic sector of the country. It contributes for 58 per cent of the PIB in 2002 against 35 % in 1985 and less than 10 % in 1970. That important part of the agricultural sector in the PIB is due to high contraction of the mining sector and other sectors for economic activity. It used to provide 17% of the value for exports in 1995 but exportations of the exports products have declined between 1959 and 1996.

In 2002, the agriculture sector used 61 % of the population and contributed to the wellbeing of 70% (39 million people) against 63% in 2000. With an annual growth rate of 2% (below the demographic growth) the agriculture sector does not cover the national needs for all products. Hence 11% of grains are imported .The country is importing and sometimes to humanitarian aid to feed its population because in rural area 73% of the population suffer from malnutrition and 30% of the children of less than 5 years of chronic malnutrition against 22.4 per cent in urban area.

Table B.1 Main Features of DRC

Caractéristiques du pays et population

Superficies physiques			
Superficie du pays	2002	234 486 000	ha
Superficie cultivée (terres arables et cultures permanentes)	2002	7 800 000	ha
• en % de la superficie totale du pays	2002	3	%
• terres arables (cultures temporaires + prairies et jachères temp.)	2002	6 700 000	ha
• cultures permanentes	2002	1 100 000	ha
Population			
Population totale	2004	54 417 000	habitants
• dont rurale	2004	68	%
Densité de population	2004	23	habitants/km²
Population active	2004	22 644 000	habitants
• en % de la population totale	2004	42	%
• féminine	2004	43	%
• masculine	2004	57	%
Population active dans le secteur agricole	2004	13 880 000	habitants
• en % de la population active	2004	61	%
• féminine	2004	53	%
• masculine	2004	47	%
Économie et développement			
Produit intérieur brut (PIB)	2003	5 600	millions de $EU/an
• valeur ajoutée du secteur agricole (% du PIB)	2002	57.9	%
• PIB par habitant	2003	106	$EU/an
Indice de développement humain (plus élevé = 1)	2002	0.365	
Accès aux sources améliorées d'eau potable			
Population totale	2002	46	%
Population urbaine	2002	83	%
Population rurale	2002	29	%

There are two types of agriculture: modern sector with big agricultural land or livestock and traditional of family type where small areas are cultivated with traditional methods. The small farms are around 3 to 4 millions covered on 4.5 to 6 millions of ha. Each family cultivates on average 1.5 ha. The farming system is not very productive and the yield is in function of the area less than the productivity of the unit surface. The farming system for the local production are mainly depending on rain and the major crops the tube, the plantain banana, the maize, rice , ground nut, beans and the palm oil. The modern farming system is essentially related to agriculture export (coffee, the, palm oil, hevea, cacao, quinquina, sugarcane). Recently the peri urban area of the cities saw an increase in production for the irrigated vegetables

The hydrographical network is dense. It has notably around 30 main rivers with a total length of 20,000 km of length. Those rivers flow into the Congo River which is 4670 km of length which ha the second highest discharge on the world (30,000 m3/sec.). The DRC is the most endowed on the continent with an average of internal renewable resources of 900 Km^3/year which represents a quarter of the water resources on the African continent.

That potential is immense and hardly exploited. With a total capacity of 44,000 megawatts, the hydroelectric dam of Inga on Congo River can cover the energy needs of the whole Africa but only 650 to 750 MW are produced because of poor management of the 2/3 of the turbines.

International Waters: The DRC is included in Congo Basin with 8 other countries : Angola, Burundi, Cameron, Republic Centre africaine, Congo, Rwanda, Tanzania and Zambia and in the Nile Basin with 9 other countries Burundi, Egypt, Eritrea, Ethiopia, Kenya, Rwanda, Sudan, Tanzania, and Uganda. She is a member of Nile Basin Initiative launched in 1999.

Irrigation and drainage development: The potential for irrigation is estimated to vary between 4 to 7 millions of ha including small perimeters of valley bottoms. Despite that huge potential, the irrigated perimeters are not more than 13,500 ha in 1995. The perimeters with total control of water covered 10,000 ha and the equipped area for 500 ha. The area of valley bottoms and swamps not equipped represented then 2,000 ha and the recession cultures for 1,000 ha (Table B.2) From the repartition of size of perimeters in total or particle control, around 15 per cent are perimeters with less than 100 ha, 2 per cent of the perimeters of 100 to 1,000 ha and 83 per cent of the perimeters with more than 1,000 ha. In 2000, it was estimated that only 6,800 ha of equipped area were in fact irrigated.

Table B.2 Irrigation Situation in DRC

Irrigation et drainage

Potentiel d'irrigation			7 000 000	ha
Contrôle de l'eau				
1. Irrigation, maîtrise totale/partielle: superficie équipée		1995	10 000	ha
- irrigation de surface		1995	10 000	ha
- irrigation par aspersion			-	ha
- irrigation localisée			-	ha
▪ partie irriguée à partir des eaux souterraines		1995	0	%
▪ partie irriguée à partir des eaux de surface		1995	100	%
2. Zones basses équipées (marais, bas-fonds, plaines, mangroves)		1995	500	ha
3. Irrigation par épandage de crues			-	ha
Superficie totale équipée pour l'irrigation (1+2+3)		1995	10 500	ha
▪ en % de la superficie cultivée		1995	0.13	%
▪ augmentation moyenne par an sur les .... dernières années			-	%
▪ superficie irriguée par pompage en % de la superficie équipée			-	%
▪ partie de la superficie équipée réellement irriguée		2000	70	%
4. Marais et bas-fonds cultivés non équipés		1995	2 000	ha
5. Superficie en cultures de décrue non équipée		1995	1 000	ha
Superficie totale avec contrôle de l'eau (1+2+3+4+5)		1995	13 500	ha
▪ en % de la superficie cultivée		1995	0.17	%
Périmètres en maîtrise totale/partielle	**Critère**			
Périmètres d'irrigation de petite taille	< 100 ha	1995	1 480	ha
Périmètres d'irrigation de taille moyenne	> 100 ha et < 1000 ha	1995	220	ha
Périmètres d'irrigation de grande taille	> 1000 ha	1995	8 300	ha
Nombre total de ménages en irrigation			-	
Cultures irriguées dans les périmètres en maîtrise totale/partielle				
Production totale de céréales irriguées			-	tonnes
▪ en % de la production totale de céréales			-	%
Superficie totale en cultures irriguées récoltées			-	ha
▪ Cultures annuelles/temporaires: superficie totale			-	ha
- canne à sucre			-	ha
- riz			-	ha
▪ Cultures permanentes: superficie totale			-	ha
Intensité culturale des cultures irriguées			-	%
Drainage - Environnement				
Superficie totale drainée		1995	3 900	ha
- partie de la superficie équipée pour l'irrigation drainée			-	ha
- autres surfaces drainées (non irriguées)			-	ha
▪ superficie drainée en % de la superficie cultivée		1995	0.1	%
Superficie protégée contre les inondations			-	ha
Superficie salinisée par l'irrigation			-	ha
Population touchée par les maladies hydriques liées à l'eau			-	habitants

The systems of irrigation at small scale with a major participation of farmers are considered performing well .more over the horticulture and irrigated rice production have a high potential productivity and more income on sites of Pool Malebo (vast area under inundation by seasonal flows and situated between Kinshasa and the Congo River with a potentiality of 6000 ha and Loma (potentiality of 400 ha) because of the proximity of Kinshasa and Mbanza Ngungu. More often, the irrigation and drainage are often badly done. Fields for horticultures (urban and peri urban area) suffer, according to the seasons, for excess of water (bad drainage) or lack of water (not enough water or irrigation equipment non available or badly used)

The national program for rice production (PNR) has managed 150 ha including the reparation of irrigation canals and drainage and the distribution of pumping material. It has also managed a total of 300 ha of valley bottoms in the Kikwit region, the Ruzizi valley in the south of Kivu, Lodja in East Kasai, Mbandaka-Bikoro, Gemena-Karawa and Bumba in the Equator Province. Its office of rural engineering has done some studies and pls related to small managements and assisted farmers in the construction of their perimeters. Finally a project for management of 2800 ha in the marshlands of Pool Malebo was in the stage of finalization in 1996. The crop the most irrigated remain as the sugar cane. The irrigation scheme at Kiliba in the south of Kivu is important for sugar production.

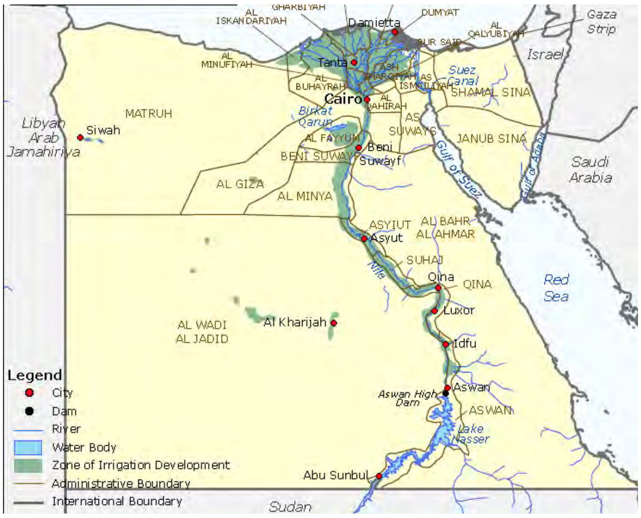
In DRC, the land tenure is controlled by the law N 73-021 of 20 July 1973 modified and completed by a law N 80-008 of 18 July 1980 which makes the state as the only owner of the soil and under ground. The law stipulates the agreement of the Chief of the clan before the final authorization by the administrative chief for the attribution of the land. The access to land is unequal despite the abundance because of the traditional factor which is still in place and which allows the possession of vast area by the chief of clans.

The water are under exposure for various forms of general pollution from the towns, complex pollution coming from the industrial activity and the transport (notably on the lakes, the Congo river and other rivers) pollution related to oil activity, especially on Atlantic area where two companies are producing oil and refine the imported oil.

ANNEX C – EGYPT COUNTRY OVERVIEW

Egypt

Egypt is the "gift of the Nile" according to Herodotus the Greek historian 25 centuries ago and is divided into three main geographical regions (i) Nile Valley; (ii) Eastern desert; (iii) Western desert. Its reliance on the Nile is reflected in the fact that 90% of the population live on 5% of the land area around the stem of the Nile River and the Delta. Just north of Cairo, most of the agricultural land is located in the fertile Nile Delta that is about 250 kilometres wide at the seaward base and about 160 kilometres from south to north. In addition to the Nile Basin that covers 326,751 km^2 (33%), of the total area of the country, Egyptian territory comprises the Northern Interior Basin[144] covering 520,881 km^2 (52%), the Mediterranean Coast Basin covering 65,568 km^2 (6%) and the Northeast Coast Basin, a narrow strip of 88,250 km^2 (8%) along the coast of the Red Sea.



The Delta region contributes about 80% of all cultivable land in the country and despite the extremely limited land available for agriculture urbanization of these lands is growing. Between 1972 and 1990, urban areas increase form 3.6% of the total Delta land area to 5.7%. About half of this increase occurred between 1984 and 1990 meaning that by 2010, as much as 12% (302,500 ha) can be expected to be lost to urbanization. This change is not restricted to the delta area, with cities and large villages growing by 37% in the 18 year period and small villages was more than twice, or 77%. Water savings from these areas are allocated elsewhere and since the late 1960s, the Government of Egypt (GOE) has supported commercial farmers in reclaiming desert lands. This compensates both for the loss of agricultural land in the Delta region and for the loss of jobs by providing opportunities to generate new jobs, increase production and widen the development base. About one third of the Egyptian labour force is engaged directly in farming and many others work in the processing or trading of agricultural products. Most Egyptian agriculture takes place in some 30,000 km^2 (~3% of Egypt territory) of fertile soil in the Nile Valley and the Delta that alone contributes to 80% of all cultivable old lands.

Issue/Constraint: . *Increases of urbanization are having a significant impact on available agricultural area within a specific command area and not only increases unit costs per ha. It also reduces access and thereby interferes with the upgrading and improvement of I&D systems increasing costs and times for implementation of changes and reforms.*

A high growth was experienced in the 2nd half of 1990s following the adoption of a structural adjustment program. After the strong run-up of the late 1990s, GDP growth rate decelerated between 2000 and 2003, averaging only around 3.2%/an. The loss of growth momentum was accompanied by a decrease in both private and public investment[145] with the former declining from around 11% of GDP in 1998 to 6% in 2005/06. This is a cause for concern, as private investment must serve as the main engine of future growth and employment. The agriculture

[144] Including the Qattara Depression.
[145] Public investment has fallen from around 15% of GDP in 1998 to around 8% in 2005.

sector contributes 15% of GDP[146], 12% of export earnings and employs 27% of the labour force[147]. Until the end of 1970s, government provide significant support in agricultural production, trade and prices. Since then, liberalization and privatization reforms have taken place with farmers selecting their own crops with most farm inputs/outputs priced at market prices. Government is moving towards improving farm output per unit of water and land, in line with water resources plans of MWRI.

Issue/Constraint: . *The changing needs towards export markets needs to be supported by good advice on export quality and requirements and how the farmers can achieve this.*

Total water withdrawal in 2000 was estimated at 68.3 km^3. This included 59 km^3 for agriculture (86%), 5.3 km^3 for domestic use (8%) and 4.0 km^3 for industry (6%). Apart from that, 4.0 km^3 were used for navigation and hydropower. Groundwater extraction in 2000 was 7.043 km^3 comprising 6.127 km^3 from the Nile Basin (seepage waters), 0.825 km^3 from the eastern and western deserts, i.e. mainly the Nubian Sandstone aquifer and 0.091 km^3 from shallow wells in Sinai and on the north-western coast. Reuse of agricultural drainage water, returned to the rivers, in irrigation amounted to 4.84 km^3/an in 2001/02. Of the 2.97 km^3/an of treated wastewater, 1.5 km^3/an is reused for irrigation, while the rest is pumped into main drains where it mixes with drainage water and is then used for irrigation. Treated wastewater is usually used for landscape irrigation of trees in urban areas and along roads.

Issue/Constraint: .*There is insufficient water to meet all demands from competing users and the potential for increasing the amount of water available is limited.*

All drainage water in Upper Egypt, south of Cairo, flows back into the Nile and the irrigation canals; this amount is estimated at 4 km^3/an. Drainage water in the Nile Delta is estimated at 14 km^3/an. Treated domestic wastewater in 2001/02 was estimated at 2.97 km^3/an. There are several desalination plants on the coasts of the Red Sea and the Mediterranean to provide water for seaside resorts and hotels; total production in 2002 was estimated at 100 million m3. Estimates of the potential of non-renewable groundwater in the eastern and western deserts, mainly from the Nubian Sandstone aquifer, vary from 3.8 km^3/an to 0.6 km^3/an; the latter estimate is defined as an indicator of exploitability over a period of time, where the time is not given.

Table C.1 Water Availability in Egypt

Water Resources	Present Quantity (2004) (Milliard m^3 in year)	Future Quantity (2017) (Milliard m^3/year)
Nile Water	55.5	57.5

[146] National Bank Egypt, economic periodical, 58, 59, 2005 -2006
[147] Farm mechanization and labour migration to Arab countries coupled with an increase in education have caused agricultural wages to decline compared with other sectors (industry, tourism, etc) and the share of agriculture labour in the national employment is decreasing annually.

Rainfall Harvesting	1.0	1.5
Deep Groundwater	0.9	3.5
Shallow Groundwater	5.0	7.6
Drainage Reuse	4.9	8.4
Treated Sewage	0.7	2.5
Desalination	0.1	0.2
Water Saving by IIP	1.0	4.0
Total Water Resources	69.1	85.2

Source: FAO, 2005; Dr Gamal Elkassar, NC-Egypt

The main challenge for the sustainability of water resources is the control of water pollution. The Ministry of the Environment is observing the enforcement of the new legislation regarding the treatment of industrial and domestic wastewater. MALR is also advocating organic farming and limiting the use of chemical fertilizers and pesticides to reduce crop, soil and water pollution. In addition, present policy is to minimize the use of herbicides and to depend mainly on the mechanized control of submerged weeds and water hyacinths.

Issue/Constraint: .*There is increasing levels of pollution caused by overuse of fertilisers and pesticides and from the spread of urban development.*

Bilharzia, or Schistosomiasis, is still a common disease in rural areas in Egypt but its occurrence has greatly decreased with the provision of improved drinking water to most rural areas, periodic examination of school children, free medical treatment and extension programmes to educate people on ways of protecting against the disease. The Ministry of Health and Population announced that Bilharzia cases in the examined samples of rural population in 2001 were only about 4 percent. Malaria is rare in Egypt

Groundwater is quickly depleting with a commensurate effect on overall water quality. 11% (361,176 ha) are irrigated from groundwater in the provinces of Matruh, Sinai and New Valley. To resolve this problem, GOE has been reviewing options to replace groundwater with surface water irrigation. The goal is to minimize, if not totally halt the depletion o f the groundwater resource. To achieve this goal, GOE wishes to implement a surface water conveyance system and to introduce important reforms in the sector, particularly full cost recovery tariffs and volumetric pricing. Such reforms are part of the GOE's own Integrated Water Resources Management Action Plan (IWRMAP) developed in 2005 to ensure correct incentives to conserve and utilize water more efficiently.

The Nubian Sandstone aquifer located under the Western Desert is considered an important groundwater source. The volume of groundwater entering the country from the Libyan Arab Jamahiriya is estimated at 1 km^3/an. Internal renewable groundwater resources are estimated at 1.3 km^3/an, bringing total renewable groundwater resources to 2.3 km^3/an. The main source of internal recharge is percolation from irrigation water in the Valley and the Delta.

Issue/Constraint: *The quality of groundwater is declining and there are excessive levels of depletion of reserves to compensate for insufficient availability of surface water sources. More information is needed on the extent of groundwater resources that extend across various Nile basin Counties and the limit of safe development.*

Policies and legislation: The main water and irrigation strategy is concerned with the development and conservation of water resources. This is done through adopting water rotation for irrigation canals, limiting the rice growing area, lining irrigation canals in sandy areas and prohibiting surface irrigation in the new developed areas outside the Nile basin. Recent water resources policies include different structural and several non-structural measures. Structural measures include irrigation structures rehabilitation; improvement of the irrigation system; installation of water level monitoring devices linked to the telemetry system; and expansion of the tile drainage system. Non-structural measures include expansion of water user associations (WUAs) for irrigation ditches; establishment of water boards on branch canals; promotion of public awareness programmes; and involvement of stakeholders. The legal basis for irrigation and drainage is set in Law No. 12/1984 and its supplementary Law No. 213/1994 which define the use and management of public and private sector irrigation and drainage systems including main canals, feeders and drains. The laws also provide legal directions for the operation and maintenance of public and private waterways and specify arrangements for cost recovery in irrigation and drainage networks. The most recent water policy was drafted in 1993. It included several strategies to ensure satisfying the demands of all water users and expanding the existing agricultural area at that time of 7.8 million feddan (about 3.12 million ha) by an additional 1.4 million feddan (about 560 000 ha).

Issue/Constraint: *.More coordination is needed between the various organisations involved in irrigation development and crop production to ensure a greater take up of ideas and new approaches. The current weak links between research and farmers or communities must be seriously addressed.*

The climate is categorized as arid in the north (Alexandria) to extremely arid in the south (Aswan). During summer, temperatures are extremely high, reaching 38^0C - 43^0C with extremes of 49^0C in the southern and western deserts. The Mediterranean coast has cooler conditions with maximum temperatures of 32^0C. Daily evaporation ranges from 1.5-8.5 mm with a mean daily reference crop evapotranspiration from 2-10 mm. Overall average annual rainfall is about 18 mm with most rain occurring on the northern coast that receives about 150 mm/an. In many districts (southern Upper Egypt, Sinai, and along the Red sea coast) measurable rainfall may be encountered once every 2-3 years, sometimes developing into very short, but destructive, flash floods. Precipitation that takes place in winter / late autumn accounts for 1.3 bcm/an of internal renewable water resources, recharging shallow aquifers, and to a lesser extent supplying surface water resources.

Agriculture without irrigation or water harvesting is not possible and irrigated crop production is a major economic activity in Egypt and thus a major water consumer, accounting for about 95% of the total net water demand. About 97 % of annual renewable water resources are supplied by the Nile River with 55.5 bcm/an out of an average flow of 84.0 km^3/an. reaching Aswan being allocated to Egypt according to the Nile Water Agreement (1959)[148]. Renewable water resources are thus estimated at 56.8 bcm/an, equivalent to 800 m^3/capita/an[149].

[148] This allocates 18.5 bcm/yr to Sudan with an estimated 10 bcm/an. Being lost in evaporation from Lake Nasser reservoir.
[149] This is projected to rise to 600 m3/capita/an. by 2025.

Issue/Constraint: *High temperature in the dry season is unsuitable for some varieties of fruit plants like grapes, peach, apple and apricot.*

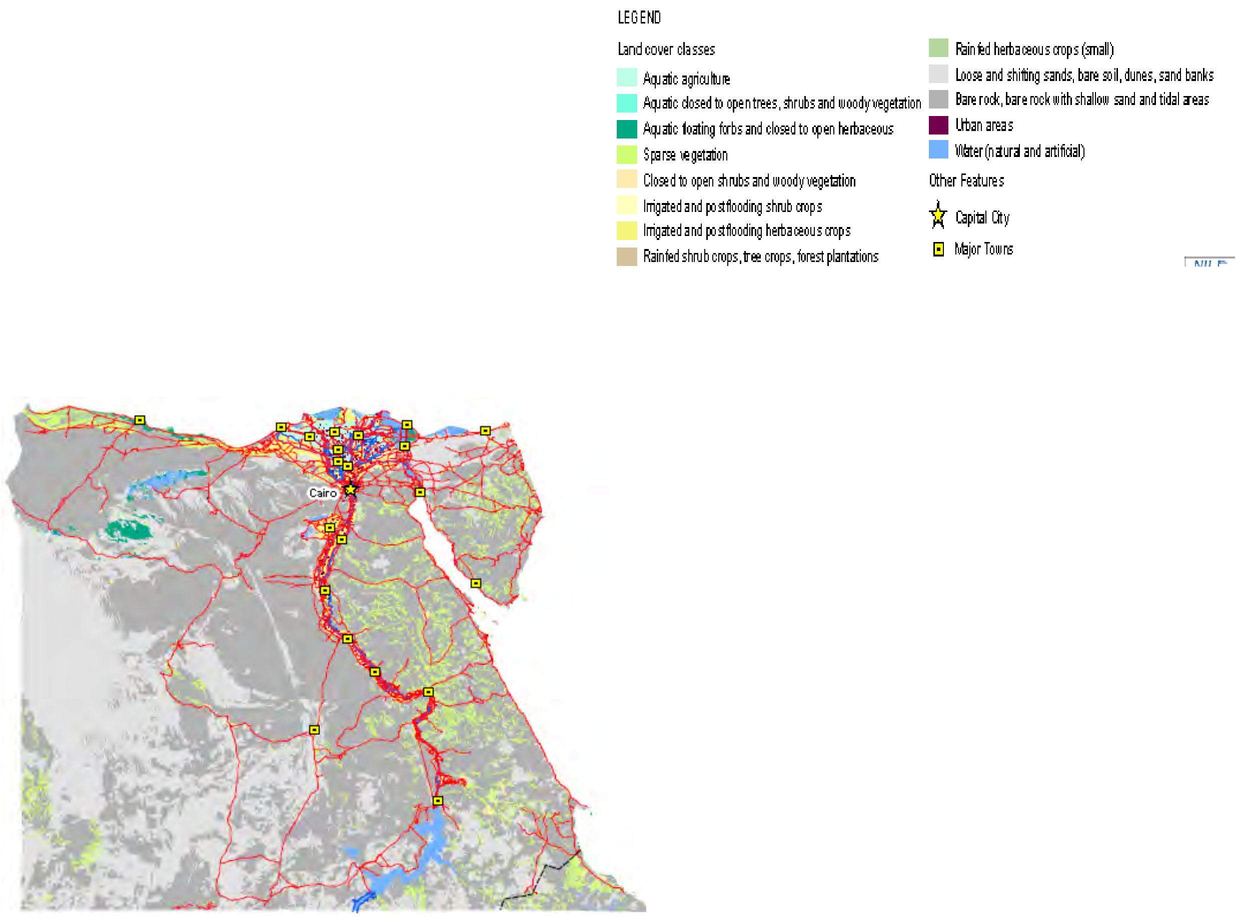
Water demand is rapidly increasing due to the growing population that has risen from about 40 million in 1978 to about 72 million in 2004 and is expected to reach around 90 million by 2020. More than 95% is concentrated in the Nile Valley and the Delta. This creates an important challenge for Egypt in satisfying the future water demand for water by agriculture, horizontal expansion in the desert areas, industrial growth, new and existing community expansions etc. More efficient use of present resources and, if possible, to develop additional water resources needs serious action now.

Issue/Constraint: *Much more practical emphasis is needed to ensure that the message is understood by farmers and that alternatives are presented to them.*

Irrigated agriculture: Around 3.4 million ha (3.4% of the total area of the country) is intensively cultivated annually[150] and 85% of this is in the Nile Valley and Delta. The irrigation system in the old land of the Nile Valley is a combined gravity and water lifting system (lift: about 0.5-1.5 m). The irrigation system in the new lands (reclaimed areas) is based on a cascade of pumping stations from the main canals to the fields, with a total lift of up to 50 m. Surface irrigation is banned by law in the new reclaimed areas, which are located at the end of the systems, and are more at risk of water shortage. Farmers have to use sprinkler or drip irrigation, which are more suitable for the mostly sandy soil of those areas.

Egypt's irrigation system extends some 1,200 km. from Aswan to the Mediterranean Sea and includes 2 storage dams at Aswan, 7 major barrages on the Nile that divert river water into an extensive network of irrigation canals. This includes 13,000 km of main public canals, 19,000 km of secondary public (Branch) and 100,000 km of tertiary private watercourses (mesqas) that form the main distributaries to farmer's fields. Complimentary drainage networks cover about 272,000 km with 17,500 km of main drains, 4,500 km of open secondary drains and 250,000 km of covered secondary & tile drains. Holdings average less than 1.9 fed (0.8 ha)[151], one of the lowest in the world. The most limiting resource for Egyptian agriculture is irrigation water. Management of its water resources has always been a central feature of the country's development strategy.

[150] Average cropping intensity of 176 percent.
[151] 59% of Holdings < 1 feddan; 23% from 1-3 feddan; 13% 5-10 feddan; (2000 agriculture census).



Mesqas are channels serving 100-500 feddans and they in turn feed "marwas" that are farm ditches serving 10-100 feddans. The mesqa and marwa systems are owned, operated and maintained by farmers. Distribution and farm-level delivery of water is carried out according to a complex framework of canal-level rotation coupled with rotation between farmers at mesqa level. Typically, farmers in historically cultivated old lands receive water in the mesqas one-half meter below the elevation of their fields and then pump it into their marwas. The most pressing problems confronting the irrigation system are the limited control provided by canal structures (many of which are only partially functional), inadequate system operations, and inequitable distribution of water at the tertiary level (where 60 to 70 percent of farmers, at tail-end locations, receive very little water). In this situation, good agricultural water management is considered a key factor in ensuring food security, poverty reduction, and environmental protection. Egypt, after ages of expanding irrigation areas and improving productivity, faces a growing crisis from poorly performing irrigation schemes, slow modernization, declining investment, constrained water availability, and environmental degradation.

Issue/Constraint: *.The condition of many irrigation and drainage systems is poor and results from inadequate past funding and farmers belief that Government will provide all. Need for wide upscaling of formation of WUAs and transfer of parts of system, to them.*

Surface irrigation is widely and almost exclusively used on an area of about 3 million ha. Newly developed lands are required to use more water efficient methods (sprinkler, drip, etc) and cover just fewer than 400,000 ha. most of which are located in six governorates of New valley, Martha mattrouh, North Sinai, South Sinai and Noubaria. All new reclaimed areas (Darb El- Arbean, Toshka etc) use these new irrigation methods.

Issue/Constraint: *Poor levels of irrigation efficiency: Low application efficiency and poor choice of irrigation methods contribute to the limited understanding of efficient water use by many users.*

The agriculture year is divided into three separate seasons: winter (Oct to Feb), summer (March to Jun), and Nili (July to Sept). Crops are classified in groups (8 groups), Cereal crops (wheat, Barley, Rice, and sorghum), legume crops (Broad bean Lentil, chick peas, lupine and fenugreek), Fiber crops (Flax and cotton), oil crops (soybean, peanut, sesame and sunflower), Sugar crops (sugarcane and sugar beet), Fodder crops (clover and green fodder crops), Fruits crops, Vegetables and Onion and in addition to Aromatic and Medical plants and other vegetables and crops. Most crops are grown both in the Delta and the Valley, with the exception of rice (Delta mainly) and sugarcane (Valley). The main winter crops are wheat and clover or Berseem (*Trifolium alexandrinum*). Berseem is grown either over 3 months with 2 cuts as a soil improver (short Berseem), usually preceding cotton, or over 6-7 months, either with 4-5 cuts as a fodder crop or grazed by tethered cattle (long Berseem). Minor winter crops are, amongst others, pulses, barley and sugar beet. The main summer crops are maize, rice and cotton, the latter being the most important Egyptian export crop. In 2002, yields were 6.4 tonnes/ha for wheat, 8.1 tonnes/ha for maize, 9.4 tonnes/ha for rice and 2.6 tonnes/ha for cotton.

Cropped area and cropping pattern over the country increased from almost 5.86 million ha to 6.28 million ha between 2000/2001 and 2005/2006, about 7.2% increase. Cereals showed an annual growth rate of 2.5% whereas citrus showed an annual growth of 8.2%. Fibres and clovers showed decreased growth (-2.5% and -1.3%) respectively and legumes, sugar oilseeds and vegetables showed an increase of 1.74%, 1.91, 2.34% and 1.15 % respectively. Most crops showed an increase rate of productivity, except for cotton - the annual growth rates were 0.63 % for cotton, 2.4% for wheat, 4.1% for maize, 10% for rice, 16.2 % for tomato (different seasons), 13% for onion and 3.2% for sugarcane. Self-sufficiency has been achieved in rice, vegetables fruits, dairy products, poultry, eggs and fish, and there is surplus for export in these crops.

Issue/Constraint: *Increase in cultivated area over the last five years has been encouraging but it is still lower than the rate of increase in population estimated at 10%. Improvements in the production per capita will thus require significant improvements in productivity and hence in the way in which water is used within the systems.*

An extensive National Drainage Programme has been carried out over the last four decades to control waterlogging and salinity. The drainage system consists of open drains, sub-surface drains and pumping stations. In 2003, slightly over 3 million ha of the total irrigated area were drained, of which about 2.2 million ha with sub-surface drainage. The sub-surface drained area represents more than 65% of the total cultivated area. There are 99 pump stations devoted to the pumping of drainage effluent. The power-drained area was estimated at about 1.65 million ha in 2000. Drainage water from agricultural areas on both sides of the Nile Valley is returned to the River Nile or main irrigation canals in Upper Egypt and in the southern Delta. Drainage water in the Delta is either pumped back into irrigation canals for reuse or pumped into the northern lakes or the Mediterranean Sea.

Issue/Constraint: *High water table and low efficiency of field drains: Poor water management with excessive levels of application in some areas and inadequate levels of maintenance and reducing effectiveness of crop production improvements.*

Salinity and waterlogging are now under control in about 80% of affected areas following the installation of drainage systems. This has led to a reduction in saline areas from about 1.2 million ha in 1972 to 250,000 ha at present. Seawater intrusion is a problem in the northern part of the Delta, where groundwater becomes brackish to saline and about half of the Delta contains brackish to saline groundwater (680 -1,170 mg/litre in 2000/01). No water is pumped in the northern Delta where the rice belt is a major defence factor to keep salinity under control, as well as to stop the invasion of sea water further inland in the Delta aquifer. In the new Al Salam Canal, drainage water is mixed with Nile water at a ratio of 1:1, and the salinity of the mixed water is within safe levels.

Livestock represents 30% of the total value of agricultural production from cows, buffaloes, sheep, goat and camel in addition to poultry and bees. Livestock numbers are increasing annually in line with Governments aim of developing the livestock sector. Milk production is also important and in 2004/2005 5.7 million tons were produced (cow milk 2.9 million tons; buffalo milk 2.8 million tons).

Issue/Constraint: *Growing importance of livestock within the Egyptian farming systems is not balanced by increasing level of advice available and availability of improved varieties of livestock.*

Fish production from sea, northern lakes, coastal plains and internal water and lakes amounted to 3 million tons in 2003, with internal waters being the most important source representing 75% of the total fish production.

Water management:. The Government has initiated the process to move from its role as central (or sole) actor in developing and managing water supply systems, towards promoting participatory approaches in which water users will play an active role in the management of irrigation systems and cost sharing. Important institutional and legislative measures implemented to promote the establishment of sustainable participatory irrigation management (PIM) associations. However, despite these measures, the development of water users' associations (WUAs) as effective partners in irrigation management remains at an early stage. In new lands, the concept of PIM is not yet effectively operational for a variety of economic, financial and institutional reasons. While most settlers recognize the importance of WUAs in the equitable distribution of available water, uneven water availability, either due to design shortcomings or to lax enforcement of rules against excess abstraction by some users, has inhibited the successful operation of WUAs in many instances.

All new development areas have to use sprinkler or localized irrigation. Surface irrigation is not permitted outside the Nile Basin. The Al Salam project and the project at Toshky have been financed locally and with aid from Arab countries and international agencies. The long-term plan in Sinai is to develop 630 000 ha; the present five-year plan includes 107 520 ha in the region.

Formation of formal Water Users Associations to promote farmer involvement and participation in water management at mesqa level and to improve the efficiency of water use has been the thrust of government policy in recent years[152]. This has taken time to achieve and formation in the middle delta region has been the most successful with 38% formed, followed by 28% in middle Egypt, 28% in the west delta, 5% in the east delta and 1% in upper Egypt. For the most successful WUAs, management has now been extended to manage secondary canals by forming high level associations.

[152] Supported by the World Bank under the Irrigation Improvement Project (IIP) that includes rehabilitation and renewal of water structures, use of pipeline and raised mesqas, use of one– point collective pumping from branch canal into mesqas and land levelling using modern techniques, redesign of field irrigation systems and continuous flow (instead of rotation system).

Issue/Constraint: *The time and supported needed for formation of WUAs and for them to successfully take over management of part of the systems is often far greater than originally envisaged. Much work is required to move from theory to practice in the case of PIM.*

In line with government policy of reducing support to O&M of irrigation and drainage systems, cost sharing/cost recovery has been initiated under IIP interventions. Cost recovery systems have been established through which users pay for services and improvements of water distribution and network maintenance as well as the cost related to interventions at branch canal and mesqas.

Public/Private Managed Irrigation. The main objective of the Irrigation Improvement Project in the old lands is to improve the efficiency of water use at the mesqa level, increase agricultural production and long-term sustainability of irrigation through more efficient use of fresh water and water saving and farmer participation in system management. The frame work of IIP includes rehabilitation and renewal of water structures, use of pipeline and raised mesqas, use of one–point collective pumping from branch canal into mesqas and land levelling using modern techniques. It also includes the redesign of the field irrigation systems and most importantly, the continuous flow (instead of rotation system) is considered the main core of IIP intervention.

Issue/Constraint:.*This approach seems to be successful, but is unique to the Egyptian systems due to the concepts of the original designs.*

Efficiency: The estimated values of conveyance and on-farm efficiencies are in order of 80% and 70% respectively which means that the overall efficiency is in the vicinity of 55%. However, due to the recycling of drainage water the overall efficiency is increased. It is believed that this efficiency may be as high as 80% in the upper and middle Egypt where all drainage water returns to the river Nile. In the delta, the over all efficiency is estimated at 65%. Considering the amount of water entering the country from the high Aswan Dam (HAD) and the amount leaving the country as a drainage water to the Mediterranean sea and coastal lakes permits a rough calculation of overall efficiency of more than 70%[153].

Table C.2 Water Use of some crops for Agriculture Production in Egypt (2003) (000m^3)

Crops	Cultivated Area ,000.fed	Consumptive use		Actual water use		Water use efficiency%
		m^3/fed	Total m3	m^3/fed	Total m^3	
Clover	2539	2776	7048	4627	11748	60
Wheat	2506	1934	4846	2974	7453	65
Barely	2162	1786	3861	2977	6436	60
Broad bean	282	1558	439	2224	627	70
Lentil	42	1484	62	2215	625	67
Fenugreek	14	1356	19	1965	28	68
Chickpeas	15	1754	26	2698	40	65

[153] During the five years from 2000 to 2004, the estimated efficiency of conveyance at main and secondary canal level has risen from 79% to 82% and at field level it has risen from 69% to 71%.

Lupine	6	1440	9	2057	12	70
Flax	31	1489	46	2190	68	68
Onion	61	2473	151	3533	216	70
Garlic	23	1437	33	2053	47	70
Sugar beet	131	2007	263	3345	438	60
Potatoes	83	1864	155	2741	228	68
Tomatoes	179	1767	316	2561	458	69
Other veg.	286	1776	508	2574	736	69
Other	196	1775	348	2731	535	65
Maize	1580	2147	3392	3067	4846	70
Sorghum	390	2380	928	3662	1038	65
Rice	1508	4267	6435	7112	10725	60
Peanut	147	2076	305	3053	449	65
Sesame	72	2298	165	3379	243	68
Soybean	18	2527	45	3888	70	65
Sunflower	32	2365	76	3478	111	68
Sugarcane	327	8091	2646	14711	4810	55
Cotton	535	3413	1826	4875	2608	70

Source*: Computed and compiled from different sources.*

As would be expected, the summer crops are the greatest users of water (22.3 bcm) and amounts to almost 60% used in the year. Winter crops use about 10.7 bcm (28%), nili season 13.7 bcm (3.6%) and orchard crops 34 bcm (9%)[154]. The consumptive use and actual water use of some crops and water use efficiency in 2003 are given in Table C.3 below. It can be seen that water use efficiency ranged from 55% for sugarcane to 70% for maize, garlic, onion, cotton and broad bean. Improvements in these efficiencies were achieved for crops using improved water application practices such as long furrows as in case of maize, cotton, and broad bean.

Table C.3 Water use of for crop patterns, net return/m^3 in Egyptian Agriculture (2003/2004)

Crop-Pattern	Consumptive	Total return	Total costs	Net returns	Return/m3

[154] Based on measurements made in the 2003/2004 agriculture year.

	use m³	L.E			
Berseem +Cotton	4634	4875	2641	2234	0.48
Sugar beet +Maize	6412	4828	3374	1454	0.23
Onion + Cotton	6413	5814	4433	1381	0.22
Onion + Maize	4334	5472	4079	1393	0.32
Wheat + Maize	4609	5296	3424	1872	0.41
Wheat + Rice	6688	6903	3774	3129	0.47
L. Berseem + Maize	5454	6501	2751	3750	0.69
L. Berseem + Rice	7533	8108	3101	5007	0.66
Broad bean + Maize	4181	4614	3185	1429	0.34
Broad bean +Rice	6260	6221	3535	2686	0.42
Lentil + Sesame	3759	3819	2695	1124	0.30
Barely + Maize	4412	4023	2832	1191	0.27
Barely + peanuts	5480	4410	2673	1737	0.32
Tomatoes+ Maize	4220	13551	4899	8652	2.05
Sugarcane	8091	5201	3700	1501	0.19

***Source**: Statistical year book 2005, central agency for public mobilization & statistics, (C.A.P.M.A.S) pub. July 2006.*

Economics of water use in agricultural production have been estimated from the above data in terms of net returns/m³ of water used for different cropping patterns. After the agricultural reform policy was introduced with its emphasis on water use, many farmers increased the area of rice and Berseem (clover) in order to achieve high returns. In Table C.3, the returns for 15 different cropping patterns are shown[155]. The highest net return is obtained from the cropping pattern of tomatoes + maize followed by long Berseem (clover) + maize, long Berseem + rice, Berseem + cotton and then wheat + rice. For the more progressive farmers, such information will affect their choice of crops. It should be notes that some high return crop patterns (e.g. sugarcane) give low returns/m³ because of high water consumption or high cost of production and low of returns.

Issue/Constraint: *More technical support is required for the farmers, especially the resource poor farmers, to advise them on the choices of crops to grow, the relative amounts of water that each crop uses and the overall profitability of the cropping patterns.*

[155] Cropping pattern in this respect means the successive crops cultivated in one agriculture year on a specific area of land.

Water Harvesting has traditionally taken place in areas to the West of the Delta and more recently to the east of Cairo in Sinai Desert covering a total area of about 133,500 ha. All interventions aim at addressing water supply deficits (irrigation, drinking water for humans and livestock) and groundwater problems (quality and quantity). The best practices applied in North Western Coastal Zone, include (i) Land alteration techniques (Small basin, Small catch, Roaded, U shape, Water spreading, Contour ridges, Strips, Storage water and Plastic tanks) and (ii) Modern techniques (Soil covers and Soil additive). Studies have indicated the possibility to conserve about 2.0 billion m^3 /an. from flash floods[156] (concentrated in North & South Sinai, Red sea, some areas in western desert and Upper Egypt). The strategy adopted is the building dams with the stored water being directly used for irrigation, drinking or recharging the groundwater[157].

Issue/Constraint: *Siltation of such dams is a problem and care has to be exercised when examining the economics of such developments.*

Pilot projects in Wasat and Mahmoudia have shown that yield increases of 10% can be achieved for cotton (6.8-7.2 t/fed) and rice (2.75-3.1 t/fed) and maize (2.1 to 2.4 t/fed.) crops in the summer period with lower increases in the winter crop season. Further work has indicated the need to identify the hydraulic parameters of the existing aquifers (shallow and deep). It has also been shown that rainwater and floodwater harvesting have the potential to increase the productivity of arable grazing land by increasing the yield and by reducing the risk of crop damage and can contribute to the fight against desertification with tree establishment. Most of the techniques applied are relatively cheap and can therefore be a viable alternative where irrigation water from other sources is not readily available or costly.

Issue/Constraint: .*There is scope for learning more on use of spate flow for seasonal irrigation of pasture and crops from Sudan where this technique has been practices successfully for many years.*

In Table C.4 below, the main constraints identified for Egyptian farmers and water production are listed. These derive from the Rapid baseline Report as well as information provided from the World Bank supported Irrigation Improvement Project. Some key lessons set out in the Implementation Completion Report of Irrigation Improvement Project include:

- Piloted innovations that are not fully proven should probably be taken to scale through further progressive piloting; main and branch canal physical and operational measures for implementation of CF regimes should preferably be defined and established in advance of mesqa improvement programs.
- Delivery system improvements should be effected in advance of mesqa system improvements, to reduce stakeholder pressures and perceived needs for oversized system components; there should be greater and more effective design intervention, technology transfer and overview by experienced international experts, to ensure technical suitability and cost effectiveness of works designs.
- there should be an initial participatory planning and preliminary design process to develop technical options and their corresponding costs and benefits, followed by adequate presentation to, discussion with, and consent-securing from, system user organizations and operating agencies, prior to finalizing intervention designs;
- There should be early presentation, discussion and agreement with WUAs and system operating agencies on development plans and preliminary designs; establishment of WUAs and O&M training should be effected in parallel and perhaps jointly with

[156] Pilot projects have shown that harvested rainfall range from 8-12% and flash floods range from 0-62%.
[157] In South Sinai more than 25 dams have been built for this purpose.

similar institutional development and capacity building for system operating agencies:

- Greater emphasis should be given to proper and relevant O&M training for irrigation and drainage system water users; and firm and suitable arrangements should be put in place and activated for continuing technical and administrative support to the WUAs, by CD-IAS and possibly in coordination with a suitable unit within MALR's extension department.

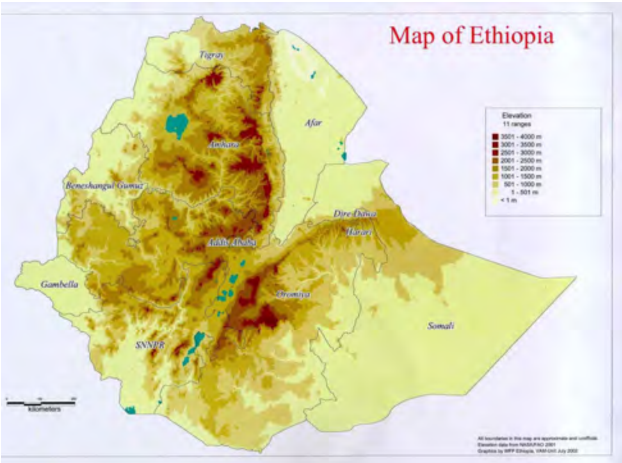
Table C.4 Main Identified Constraints - Egypt

	Constraint/Issue	Remarks
A.	**Water Resources Management**	The water resources in Egypt is very limited - water resources constraints :-
	Insufficient amount of water to meet competing uses	
	Potential for increasing water available is very	
	Surface Water	
	Irrigation water pollution.	Overcome impact of pollution of water by overuse of fertilizers and pesticides and also from increasing urban development
	Problems associated with reuse of drainage and sewage treated water.	Many farmers and uses of water are unaware of International standards required for use of sewerage effluent and reuse of drainage waters
	Groundwater	
	Limited amount of groundwater and deterioration of its quality	Excessive depletion of the groundwater reserves to compensate for insufficient availability of surface water sources
	Declining overall water quality	Due to extensive overuse of groundwater resources
	Uncertainty relating to whether it is renewable.	insufficient information available on the extent of aquifers and influence of neighbouring country abstractions on the large groundwater resources
B.	**Agricultural production**	Increasing the production requires new technology and right policy
	Insufficient returns from land and water	Many landholdings are small and farmers are not sufficiently aware of full costs of irrigation water and hence do not adopt crops
	Farmers not sufficiently encouraged to increase crop productivity	Farmers' incentives needed to increase crop production through intensification of agriculture and crop pattern changes
	Soil deterioration and low fertility.	The usable area in Egypt is about 8.4 million feddans. This area represents only 5% of the total area of Egypt. Other available land 75% of which is in the delta, comprise sand soils
	Increases of urbanization.	this has an impact on available agricultural area and interferes with the upgrading and improvement of I&D systems
	Constraints of reclaimed and sandy soil out of the delta	in areas for expansion, most of the soils are either sandy wall have potential salinity problems and this requires good management and better understanding of water needs
	Low of fertility level.	Many of the areas currently utilised extensively cultivated and many farmers do not have sufficient funds to be able to apply the
	Erosion problem and sand movements.	
	Big change in land levels.	
	Crop production constraints	
	Plant diseases,	
	Changing Climate needs different crop varieties	High temperature in the dry season is unsuitable for some varieties of fruit plants like grapes, peach, apple and apricot.
		Selection of new varieties to meet national consumers as well as for exports needs.
	Losses and weeds control.	More use if integrated pest management needed for ordinary farmers
	Productivity	
	Advanced technologies are required to face the technical constraints	Different advanced technology in term of clean agriculture, Bioagricultures, developed procedures for water management, integrated protected methods for disease control, technology of selection new varieties short duration with high yield.
	Limited real understanding by users of concept of water productivity.	Much more practical emphasis is needed to ensure that the message is understood by farmers and that alternatives are presented to them.
C.	**Extension/Support Services**	
	Inadequate support	In practice limited technical support is extended to farmers and especially for the smaller resource poor farmers.
	Marketing	
	Constraints facing free market as monopoly and control of prices	Farmers do not have easy access to markets and some control on prices that they receive.
	Advice on export quality and requirements	The changing needs towards export markets needs to be supported by good advice on requirements needed and how the
	Finance	Farmers choice of inputs is constrained by the availability of cash.
D.	**Livestock Development**	Importance of livestock within the Egyptian farming systems is not balanced by increasing level of advice available.
	Low productivity of national varieties of livestock.	
	Limited human resources in field of animal raising.	
	Animal diseases which affect productivity.	
	Farmers lack suitable extension advice.	Lock of extension services in terms of technology of animal production and negative response of farmers to the
	Unstable level of green fodder for animal during the summer season	
E.	**Irrigation development**	
	Poor levels of irrigation efficiency	Low application efficiency and poor choice of irrigation methods contribute to the limited understanding of efficient water use by many users.
	High water table and low efficient field drains.	Poor water management with excessive levels of application in some areas and inadequate levels of maintenance.
	Salinity and Alkalinity problem.	
	New areas for development need different and new skills for optimal usage.	Specific irrigation and drainage management of sandy soils
	Operation and Maintenance	Success of project development need to be upscaled and widely applied to improve O&M and hence conveyance efficiency.
F	**Water harvesting**	
	Water supply deficits (Irrigation, drinking,…)	Gulf of Suez, is an arid region that has problems of water shortage and flood damage. Very limited water resources and water
	Groundwater problems (quality and quantity)	
	Inadequate capacity	Lack of capacity for sustainable management and use of the available rainwater
G	**Institutional Aspects**	
	Research-development linkage	
	Weak research-development linkage	There is a weak links between research and farmers or communities.
	Agriculture research constraints	Transfer of research results to farmers' field are considered the main drive to increase yield and production of crops.
	Poor adoption of new results by farmers	Lack of success communication between researchers, extensions and farmers create obstacles of adopting new results
	Insufficient consistent cooperation between specialized institutes in agriculture research	Requires the integrated research in different fields of research and between different research institutions
	Lack of finance to establish data base constrains research transfer	
	Infrastructure	Insufficient support for infrastructure improvement
	Capacity building	Capacity building needed to support research services for agriculture development
	Water Management capabilities	Wider understanding by technical staff of means for managing water more efficiently and to explain to farmers the concept of productivity in relation to choice of crops and returns received.

ANNEX D – ETHIOPIA COUNTRY OVERVIEW

Ethiopia

The Nile Basin in Ethiopia is one of four major drainage systems: (i) Nile basin; (ii) The Rift Valley; (iii) Shebelle–Juba basin (iv) North-East Coast. It represents 32% of the total area of about 1.13 million km^2 and comprises the Abbay, Tekeze and Baro-Akobo rivers. Both the Blue and White Nile drains from Ethiopia and together they provide almost 70% of the annual runoff 122 billion m^3 of the country. The surface water resource potential of the country is impressive, but little has been developed so far. There are several lakes in the country (covering about 7,000 km^2), but only Lake Tana, the source of Abbay River is within the Nile Basin. Ground water resources are estimated at 2.6 billion m^3 (MOWR, 2002).



The economy is dominated by subsistence smallholder rainfed agriculture characterized by low-input and low-output system involving nearly about 84% of the 75 million[158] people. An estimated 16.6 million ha (30% of the arable land resource potential of 55 million ha) is cultivated (MOWR, 2001). Contribution of agriculture to GDP was 57% and 42% in 1991 and 2003, respectively (Andrews et al, 2005). Mixed crop-livestock agricultural production system is practiced by 80% of the country's population inhabiting the Ethiopian highland, which is the land above 1500m altitude and covering 45% of the total land mass, and in some lowlands[159]. The dominant crops grown are mainly cereals, pulses and oil crops, enset, coffee and horticultural crops.

> **Issue/Constraint:** *Declining landholding sizes due to population growth and deteriorating soil fertility are among the biggest challenges facing the agricultural production system in the highland (FAO, 2005).*

Annual agricultural water use is estimated to be in the order of 5.2 km^3, while domestic and industrial water withdrawals are estimated to be about 0.33 and 0.02 km^3 respectively (FAO, 2005). This is expected to increase to 9.0 km^3 in 2016. Even under a favourable annual growth scenario of 5% for the rainfed agriculture sector, the country could face cereal deficits of up to 6.25 million tons by 2016 (MOWR, 2001). Thus, improving water productivity is considered to have a major contribution to national food security.

Both irrigated and rainfed agriculture is important in the Ethiopian economy but virtually all food crops are rainfed with irrigation accounting for only about 3%. Export crops such as coffee, oilseed and pulses are mostly rainfed but industrial crops such as sugar cane, cotton and fruit are irrigated. Other irrigated crops include vegetables, fruit trees, maize, wheat, potatoes, sweet potatoes and bananas. There is a marked value added in irrigated agriculture.

[158] CSA population figure for July 2006
[159] Where the crops grown are drought-tolerant varieties of maize, sorghum, wheat, teff, oil crops and pulses (FAO, 2005).

A case study carried out in 2001 estimated that average yields of cereals under irrigation and rainfed conditions are 1.75 and 1.15 t/ha respectively[160].

Although there was a positive growth in agricultural production from 1991–1997, yields in the Abbay basin in Ethiopia[161] were low, averaging at 1.2 t/ha for food grains, 0.6 t/ha for pulses and 0.5 t/ha for oil seeds (BCEOM – MoWR, 1998). Tomato, onion and carrot yields ranged from 6.0–6.5 t/ha (NEDECO – DHV, 1998). Agricultural growth was driven mostly by increases in area under cultivation, rather than improvements in productivity. While the area under cultivation increased at an average rate of 5.7%/an., crop yields rose on average by only 0.4%/an. To address this, government plans to develop an additional 274,612 ha of irrigated land (127,138 ha small-scale and 147,474 ha medium/large-scale) by 2016. However, while human, land and water resources for irrigation development may be available, institutional capacity, private sector involvement and markets will constrain these plans.

Issue/Constraint: *If the country is to address its serious problems of poverty and food deficits, it must increase the extent of irrigation development and most importantly the productivity of existing irrigation systems. Improvements in rainfed agriculture will fail to make up the deficits and keep pace with the increasing demands resulting from population growth*

Ethiopia has a tropical monsoon climate with wide topographic-induced variations. Three climatic zones are identified: a cool zone consisting of the central parts of the western and eastern section of the high plateaus, a temperate zone between 1,500 m and 2,400 m above sea level, and the hot lowlands below 1,500 m. Mean annual temperature varies from less than 7−12ºC in the cool zone to over 25 ºC in the hot lowlands. Mean annual potential evapotranspiration varies between 1,700−2,600 mm in arid and semi-arid areas and 1,600−2,100 mm in dry sub-humid areas. Average annual rainfall is 848 mm, varying from about 2,000 mm over some parts of southwest Ethiopia to less than 100 mm over the Afar Lowlands in the northeast. Rainfall in erratic and most falls with high intensity, often as convective storms, and with extreme spatial and temporal variability. These results in a high risk of annual droughts and intra-seasonal dry spells and these variations are among the factors responsible for the instability of agricultural growth that declined from 2.2% in the 1960s to 0.7% in the 1970s and 0.1% in the 1980s.

Since 1991, a combination of the positive effects of policy initiatives and good rains allowed the country to achieve food self-sufficiency and export food in 1996/97. However, bad weather – a combination of rainfall deficits during the growing season and excess rainfall during the ripening and harvest season – has reversed that situation in 1997/98, demonstrating the dependence of agriculture on climatic factors[162]. Even in good years Ethiopia cannot meet its large food deficit through rainfed production.

Issue/Constraint: *Growing population pressure in the highland areas of rainfed agriculture on a rapidly declining natural resource base has secured irrigated agriculture a prominent position on the country's development agenda.*

Irrigation potential has been estimated at about 2.7 million ha, considering the availability of water and land resources, technology and finance[163]. Irrigation in Ethiopia dates back several centuries, if not millennia, while "modern" irrigation was started by the commercial

[160] The same study indicated that production costs per ha were US$ 90 for cereals, US$ 60 for pulses and US$ 290 for vegetables, while the corresponding gross incomes per ha were US$ 345, US$ 215 and US$ 1,870.
[161] The Abbay basin is endowed with better agricultural land and climatic conditions compared to other part of Ethiopia; and yet productivity is so low.
[162] BCEOM – MoWR, 1998.

irrigated sugar estate established in the early 1950s. Various sources give different estimates of irrigated area, but in 2001, the area equipped for irrigation was almost 290,000 ha (11% of the economical irrigation potential) of which 29% is located in the Nile basin. Although field assessments in small-scale irrigation projects indicate problems due to shortage of water, damaged structures and poor water management, in many places farmers are extending canal networks in some modern irrigation projects. The area under irrigation can therefore be considered more or less similar to the area equipped for irrigation. Four categories of irrigation schemes can be distinguished[164]:

(i) *Traditional irrigation schemes* (1-100 ha) developed by the farmers themselves and covering about 155,014 ha with about 639,031 farmers involved. They are mainly used for the production of vegetables for the local market and experience problems of unstable headworks and faulty systems of irrigation stemming from lack of technology and knowledge;

(ii) *Modern small-scale irrigation schemes*: (up to 200 ha) constructed by the government/NGOs with farmer participation generally based on direct river diversions with about 51,198 ha equipped for irrigation in 2004 and involving about 198,393 farmers. The operation and maintenance of the schemes are the responsibility of the water users, supported by the regional authorities/bureaus in charge of irrigation development and management. Water Users Associations (WUAs) are formally established in some schemes but traditional water management dominates in most of the modern schemes.

(iii) *Modern private irrigation*: Private investment in irrigation has recently re-emerged with the adoption of a market-based economy policy in the early 1980s. Virtually all irrigated state farms were privately owned farms until nationalization of the private property in the mid 1970s. At the end of 2000, private investors had developed about 5,500 ha of irrigated farms, distributed in Afar (37%), Oromia (48%) and the Southern Nations, Nationalities and People's Region (SNNPR) also known as the Southern Region (15%).

(iv) *Public irrigation schemes*: comprise medium/large-scale irrigation schemes (>200 ha) covering about 97,700 ha. They are constructed, owned and operated by public enterprises along the Awash River and were built in the 1960s−70s as either private farms[165] or joint ventures. No such schemes have been developed for the last 7–8 years.

Issue/Constraint: .*Insufficient information are available on the performance and details of existing small and medium scale irrigation developments. Priorities for support resulting from the greatest potential for increasing productivity need to be established.*

Community Managed irrigation schemes are those initiated by community, government or NGOs. Most indigenous irrigation schemes were initiated many generations back (more than 100 years - Annen C. 2001; IFAD, 2005). Sources of irrigation water are streams, springs, shallow wells and ponds and most are fully or partially developed for irrigation. They are characterized by the strength of the indigenous organizational structure that provides relatively better water utilization and enforcement of internal byelaws. In many of the indigenous irrigation schemes water is delivered on long rotation period (15 – 30 days), due to the limitations in the stream flow rate and seepage along the canal. Neither farmers nor the extension workers understand the need to match streamflow with size of irrigable area. Crop yields are thus low (tomato, onion and carrot were in the range of 6.0 – 6.5 ton/ha[166]). Many

[163] Source: Irrigation in Africa in figures – AQUASTAT Survey 2005. It should be noted that River Basin Master Plan studies carried out in the 1990s indicate a maximum irrigation potential of about 5.7 million ha, but about 3.6 million ha is commonly quoted as the maximum irrigation potential.
[164] Data compiled from National Consultants report and sourced from Ministry of Agriculture in 2004.
[165] Such as Tendaho Plantation run by Mitchell Cotts.
[166] Tekeze basin Master plan study, 1998

are constrained by the lack of adequate support from the extension and research system. They are also constrained by lack/weakness of community based institutions that enable collective action on common issues such as proper utilization of water and maintenance of structures.

<u>Issue/Constraint:</u> *There is a lack of Extension technical capacity in agronomy & water management with agricultural extension workers insufficiently qualified and equipped for the complex extension tasks of irrigation and drainage system design and improvement, irrigation agronomy and water management.*

Government/NGO Initiated Irrigation Schemes. During the last few decades government agencies and NGOs have intervened to develop new irrigation schemes and upgrade the indigenous ones by constructing diversion weirs, reservoirs, ponds, water tanks and shallow wells. Most do not operate at full or design capacity due to inadequate extension support[167], shortage of water caused by reservoir sedimentation or excessive seepage and reduced canal capacity (siltation; seepage: weed growth). There are also signs of lack of ownership or dependency feeling from the users' with resources sought from government and donors for rehabilitation or delayed maintenance work (IWMI et al, 2004). An examination of 6 irrigation schemes in Tigray and Amhara (FAO; 2003) identified poor water management due to inadequately organized water user associations, partial development of irrigable area and insufficient maintenance of canals and related structures.

Water was delivered by rotation to each plot regardless of crop water requirement, resulting in water theft and breaching of canals to divert additional water to farm plots. Crop production was determined according to family subsistence needs rather than reflecting the profitability of the crops as markets for higher value crops had not been secured and extension support lagged behind construction.

<u>Issue/Constraint:</u> *The organizational structure of indigenous irrigation schemes has a vital role in the sustainability of small scale irrigation schemes with members fully participating in maintenance activities and having a firm stand against water theft and observance of unwritten byelaws and elected leaders. These attitudes are contrary to those in many Government/NGO initiated schemes.*

Public Irrigation Schemes[168] (PMI) include large (>3000 ha) and medium (200 – 3000 ha) scale irrigation that started with the development of Amibara irrigation project[169]. About 10,285 ha of land were brought under gravity irrigation on the scheme by the end of 1982, but after 5–8 years of operation 10% (1,300 ha of Banana Plantation[170]) was abandoned due to salinity resulting from insufficient drainage[171] and lack of appropriate water management system. Other large public irrigation schemes that were built towards the end of the 80s, were suspended from 1992 – 1998 with a total of 21,000 ha of irrigated state farms in the Awash and Rift valleys abandoned/suspended. The main reasons were the need to reallocate land from public sector to peasant farmers, problems associated with poor management, inappropriate O&M and loss of land due to soil salinity and flooding problems (Annen, 2001). Fincha sugar plantation (6,500 ha) is the only large scale public irrigation scheme located in the Nile basin and it is currently operating successfully. Estimates of irrigation efficiencies for surface irrigated PMI in the Awash River Basin were in the range of 30 – 55%.

[167] Yaicob Likke, 2003; Landell Mills, 2004; IWMI et al, 2004 and IFAD, 2005.
[168] These schemes are scheduled for privatisation although a firm timetable has yet to be prepared.
[169] Other former private irrigation developments and estates growing cotton, sugar and other crops were brought into the public domain following nationalisation in the 1970s. Amibara was the first new project developed in the Public sector following this period.
[170] Communication to EWUAP, Ayalew Nigussie, ENTRO, 2008.
[171] The farm development did not include the construction of drainage system.

Issue/Constraint: *Performance of the large scale and public managed irrigation schemes has been very low. These offer the greatest possibilities for improved productivity and for meeting the demands for food within the country. Expert advice on improvements and possibilities must be provided to the Federal/Regional Governments who generally lack sufficient experience in managing such systems.*

Of growing importance are the private estates growing a variety of crops including cut flowers, fruits and vegetables under drip and sprinkler irrigation and covering more than 1,000 ha[172].

Irrigation methods: Surface irrigation is used throughout the country with only 2% using sprinkler irrigation for sugar cane production. Localized irrigation has recently started in Tigray and Amhara regions for small scale irrigation and on many water harvesting sites. Pump irrigation by a group of farm households and private farms is practiced in some areas, while treadle pumps are also used in some areas. Spate irrigation and flood recession cropping are practiced in lowland areas particularly in Dire Dawa, Somali, East Amhara, and Tigray.

Irrigation Efficiency used in design is 50% - 60% based on recommendations in FAO publications rather than field experience that indicated lower figures (34 – 54%)[173]. When farmers plant a range of crops on an individual basis without varying or coordinating planting dates, systems are unable to cope with the variable demands for irrigation water during the growing season.

Issue/Constraint: *There is a significant gap between the recommended and currently applied agronomic and water management practices. Higher levels of advice are needed by all irrigation schemes and a better system of providing suitable extension services for irrigated areas is needed as to include this with rainfed extension services has not been successful.*

Development costs per hectare of small-scale irrigation schemes are US$ 1,760−2,940 for direct river diversion schemes and US$ 4,700−7,100 for schemes requiring micro dams, while the respective annual operation and maintenance (O&M) costs per hectare are US$ 70−120 and US$ 160−240 respectively. In 1998, development costs for public surface irrigation schemes (large- and medium scale) were estimated to be in the range of US$ 3,300−12,800/ha, with the average cost being US$ 8,100/ha. This high cost is due to the fact that the construction of expensive headworks is included in the calculation. Annual O&M costs for these schemes are US$ 60−220/ha. The cost of complete sprinkler and localized irrigation installation is about US$ 5,160/ha and US$ 5,560/ha respectively.

Issue/Constraint: *The most cost effective means of developing irrigation is through the rehabilitation and upgrading of existing developments. To achieve this, much more detailed information is needed on the currently developed 200,000 ha of SSI.*

Water management of small-scale irrigation schemes is the responsibility of the farmers, mainly through informal/traditional community groups. Some formal Water Users Associations (WUAs) have been established and apart from the extension and training services provided to them by MoA/BoA, no institution is directly involved in water management in smallholder-irrigated agriculture. Once construction has been completed, the schemes are handed over to the beneficiaries but maintenance remains the responsibility of the regional governments. The absence of any appropriate local-level organs to cater for

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172 For more information contact Ethiopian Horticulture Producers and Exporters Association (www.business-ethiopia.com/associations.html#horticulture);
173 Tekeze basin – Tigray Region

small-scale irrigation has resulted in a lack of guidance in irrigation operation and maintenance at a community level. With an increase in irrigated areas and more users, irrigation water management and rules for water allocation are becoming more complex and problematic. Disputes are already common, especially between upstream and downstream users. Decentralization to Regional Governments was completed in 2003, with the process of management at lower levels under way with regional and lower level administrations becoming more autonomous in aspects related to irrigation development and water management. The strategy is to establish WUAs before projects are implemented and to strengthen them through both training and involvement in the process so that they can take over the responsibility of operation and water management when construction is completed.

Issue/Constraint: *The prevailing institutional problems are (i) institutional instability (in the irrigation sector) and (ii) the irrigation management aspect is not adequately addressed in the organizational structure of the government agencies.*

Formal Water Users Association and informal/traditional community groups are responsible for the water management of CMI schemes. In those schemes built in the middle 1990s, WUAs were organized prior to the completion of construction works with responsibility handed over to the WUA on completion. Concurrently, the WUA executive committee members were trained in basic irrigation O&M. However, after transfer of management responsibilities to the WUA, the irrigation water management efficiency decreased due to insufficient extension support (IWMI et al 2004).

Issue/Constraint: *Insufficient attention was paid to proper establishment & empowerment of WUAs who were insufficiently trained to manage schemes in a technically, economically and socially sustainable way. Their involvement has not been sufficiently participatory resulting in collapse of the WUA once project support has been removed.*

Water Charges/fees: Water charges related to domestic water supply apply throughout the country. The only irrigation water charge that has been in effect is at the Awash Valley irrigation farms, which is 3 Birr per 1000 m^3 of water. However, there is no detailed legal ground to support the implementation of the water charge. There were times when the clients failed to effect payment and the responsible agency was unable to enforce payment in arbitration and/or litigation[174]. This was attributed to the lack of appropriate regulations.[175] Some of the WUAs do have byelaws but in many cases are breached or not observed. On the other hand, indigenous irrigation schemes have unwritten but effective byelaws that have no legal basis.

Issue/Constraint: *Conflicts between upstream and downstream water users are increasing in many parts of the country. New diversions or pumps are being installed upstream of existing diversion weirs resulting in shortage of water for the existing CMI schemes. Such cases are being taken to the court and other authorities, but it appears there would be no immediate solution as there is no legal right to water.*

Marketing of crops and market prices in rural areas presents major challenges to increased crop productivity. Farmers in southern Ethiopia used to produce cotton under irrigation but bananas, papayas and vegetables are now preferred as a result of the unattractively low prices of cotton. Similarly, *teff,* which is the staple food for a significant proportion of Ethiopians and which has a low water demand, is presently grown under irrigation, but because of its low

[174] Personal communication with Team leader (a)Team Leader, Water Utilization Control and Structure Safety Follow-up Team, MOWR; and (b) Team Leader, Irrigation Team, MOWR.
[175] Based on personal observation and also communication with (a) Head, WH and SSI Department, MOARD; (b) Team Leader, SSI Team MOARD; (c) Team Leader, Water Utilization Control and Structure Safety Follow-up Team, MOWR; and (d) Team Leader, Irrigation Team, MOWR.

productivity and high labour demand it may be replaced by another crop. Hence, cropping patterns will have an impact on agricultural water demand. Farmers in remote areas grow more of maize (>50% of crops grown), which is not a high value crop[176], as they do not have markets or support for the cultivation of higher value crops. This is exacerbated by the absence of processing facilities for perishable products such as fruits and vegetables The farmers' reasons for growing more of maize were that it can be consumed directly and the stalk can be used as source of feed and fuel, it is less laborious and not perishable and the seed and pesticides required for growing horticulture are expensive and not available easily (IWMI et al 2004).

Issue/Constraint: *There has been oversupply at harvest time & depression of prices. Insufficient advice on planning of crops and staggering of crop planting dates has been available to farmers.*

The problems in linking irrigated farms in remote areas to markets which can absorb their production are related to one or a combination of the following: difficulties in physical access; the domination of the market by traders who dictate price to farmers who have no bargaining power, and the smallness of the local market (IFAD 2005). Moreover, cropping is not staggered to ensure continuous supply of produce and stabilize prices. Often, there is surplus supply congested within a short time at harvest, becoming a cause for depressing prices of vegetables. The implication of depressed vegetable prices is that the income of the farmers is too low to repay credit taken for farm inputs let alone to cover the compulsory operation and maintenance cost of the irrigation scheme. For example, Meki-Ziway irrigation scheme (in Oromia region) failed largely because farmers could not carryout maintenance and could not afford the electricity fee to run the pumps (Awulachew 2005).

Issue/Constraint: *Poor prices received by farmers as there have been poor market linkages and domination of the market by traders who dictate prices to farmers.*

Operation and Maintenance: The absence of appropriate support at Wereda level is the major cause for the lack of guidance in irrigation operation and maintenance (MOWR, 2001). In many irrigation schemes, maintenance duties are not properly done. This is reflected by inefficient scheme performance resulting from poor canal maintenance, such as no removal of silt and weeds, no repair of breached sections. These problems in turn cause a reduction in canal capacity leading to reduced water supply for irrigation. A typical example of such problem is at Doni Kombe CMI situated in Awash basin – Oromia region, where the canal capacity was reduced such that it supplied water to only 80 ha out of the total irrigable area of 195 ha (IWMI et al 2004). On the other hand, there are some WUAs that successfully achieved effective water distribution mechanism different from original designs and conduct successful scheme maintenance activities (Awulachew, 2005).

Issue/Constraint: *There has been as lack of guidance in irrigation operation and maintenance at local level, either sub district or district level and farmers have relied too much on government support for maintenance tasks – many could have been handled by participating with the community at the early stage of the project cycle.*

Livestock production is an integral part of the agricultural system of the highland and the major source of livelihood in the lowland pastoral areas. Water availability for livestock is critical in the lowlands as well as in many parts of the highland, where rainfall is inadequate

[176] In 2001, the price of maize was extremely low throughout the country at ETB 40.0 per quintal in Arba Minch, ETB 70.00 in Awassa, ETB 80.00 in Addis Ababa and ETB 90.00 in Mekelle. In some areas, price of maize as low as ETB 20/qt was reported (Annen 2001).

in amount and distribution. Most of the year, animals have to walk long distance in search of water and are usually watered once in tow to three days (McCornick P.G. et al. (eds), 2003). In the livestock sector, the main improved technologies considered include improved breeds, animal feeds, and animal health care and honey production technologies. Milk yields from improved crossbred dairy cattle was noted to be over 4000 litres over a longer lactation period as compared to 300 – 400 litres from an indigenous breed over a lactation period of eight months (Seme et al, 2004). However, in spite of these efforts, the current level of adoption was low[177] (CSA, 2005).

Issue/Constraint: *Livestock Productivity Constrained by Water Supply and also by insufficient suitable pastures throughout the year.*

Water harvesting, which includes in-situ moisture conservation and small water storages structures, is and will continue to offer good potential in water stressed areas of Ethiopia. Construction costs for the small storage structures vary from 3 to 10 US$/m^3 of water stored and returns to irrigated vegetable crops on 400-1000 m^2 plot using these stored water for irrigation enable farmers to purchase between 30 and 80% of their annual food needs (Landell Mills, 2004). The major challenges with the dugouts were the high seepage rate and high initial cost. In spite of this and that many interventions have been undertaken through campaigns in a number of regions with some good successes, farmers have failed to adopt the measures without government, donor or NGO support. The Ethiopian Rainwater Harvesting Association (ERHA) founded in 1999 is an effective and active organisation involved in all aspects of water harvesting and in disseminating ideas and technologies throughout the country. They also undertake projects funded by donors.

Issue/Constraint: *Far more emphasis needs to be given to the development of runoff water harvesting for improved agricultural production and for backyard cultivation of high value crops.*

Soil and Water Conservation: Extensive soil and water conservation works have been implemented in many parts of the country since the 70's. Various types of SWC (In-Situ WH) measures were identified, designed and implemented for each type of land use and agro ecological zones of Ethiopia (Carucci, 2000, and field observation). The measures have resulted in reduction of field slopes and runoff rates. Besides, increased biomass production and recharge of aquifer and rising ground water levels were observed. Spring recovery and/or shallow wells have provided rapid and visible benefits to communities in desperate situation. In some valley plains, composed of either heavy clay soil or loose sandy /gravely soil, water table has gone up to a depth of 1-9 meter. Such source of water is being used for domestic water supply and irrigation. But, caution and measures were lacking to balance the mining and the rate of ground water recharge.

There are encouraging approaches to implement SWC on watershed basis in Ethiopia by the Bureaus of Agriculture in collaboration with many donors. One such program is the WFP supported MERET project. The project has supported 600 micro-watersheds (200 – 500 ha) on 74 moisture deficit Woredas to undertake SWC measures and area closure. There was remarkable achievement with the physical SWC measures while the performance of the biological measures was not satisfactory (WFP, 2005). In 2004, MERET estimated the moisture retention capacity of the sediment deposited behind/above each of the SWC measures on cultivated fields. The volume of the deposition wedge of the soil due to the existence of the structure was assessed and the resultant volume multiplied by the water holding capacity of the respective textural class. The total incremental soil moisture available

[177] Area covered with improved seed = 3.67%; area where fertilizer was applied = 40.22%; area where pesticides were applied = 9.18%

within the conventional SWC measures was estimated to vary from 129 to 335 m^3/ha. This amount of moisture is made available in the soil at any one time after rainfall and can contribute to the crop's resilience to drought better than fields with no SWC measures. The crop's resilience to drought due to the presence of SWC measures was noticeable for up to 4 weeks after the rain (WFP, 2005).

Issue/Constraint: *SWC works are implemented in the catchment areas of only some irrigation schemes. Some local guidelines are available but no coordination of approach or requirement is established.*

Spate Irrigation*:* In the moisture deficit highlands, farmers divert intermittent runoff from small creeks, road side ditches or cut-off drains in to their plots. In the lowlands, the farmers construct temporary diversions across seasonal streams by piling river bed material. Such structures are liable to damage by flood and have to be reconstructed many times in a single season. Beside to structural stability, the indigenous diversion structure could not help the farmers in diverting the required flow rate. Instead, they have to construct large size canals so as to enable them divert a large volume of water within a short period. Often such flow rate results in erosion.

Hand Dug Wells with a depth of 1–9 meters are used for irrigation, domestic and livestock water supply in many places. On average one hand dug well irrigates 0.04 ha (MoARD, 2005). Water extraction means are bucket and rope, Shaduf, treadle pump, and to some extent motorized pump. Many wells are located at too close a spacing, giving too high demand on limited aquifer with resultant declining water tables, are open and unlined causing collapsing of side walls during the rains and subsequent widening of the top diameter of the well taking up more arable land.

Issue/Constraint: *Sedimentation is a major problem with many dams as design data on possible accumulation rates is based on old field information and generalised formula that underestimate actual sedimentation rates. More conservative values are needed together with catchment conservation works implemented at the same time as storage and irrigation works.*

Storage dams: Erosion in the catchments of reservoir dams is a serious problem with many reservoirs heavily silted earlier than anticipated. Limited recent data on sedimentation are available to designers and the use of older published data tends to give more favourable estimates of reservoir/dam viability[178]. Treatment of catchment areas is thus not treated with the urgency that it deserves.

Credit and Finance for Implementing SSI and WH Structures. There are many independent credit and saving institutions in the country established to provide services to the rural community. Since 2003, there have been initiatives to link the credit with WH and associated technologies. The construction of a pond was among the criteria that makes a household eligible for a loan[179] (Landell Mills, 2004). The government through the decentralized system allots a budget for the implementation of WH/SSI works. On top of this, many agencies such as WFP, GTZ, SIDA, IFAD, CIDA and NGOs (such as REST in Tigray and ORDA in Amhara) have been involved in financing capacity building and/or implementation of WH/SSI activities (King, et al., 2005).

Extension support in agronomy, water management and irrigation are weak due to limitations in technical capacity and are a major reason why farmers do not practice sustainable management and use of the available water in semi arid areas (IWMI, 2003).

[178] Examination of dams in Tigray showed that actual sedimentation rates (3,200 to 4,800 m^3/km^3,an) were nearly 4 times the predicted rates and dead storage were filled within 3-4 years. (TBWRD).
[179] Loan repayment period of 4 years with 9% interest rate

There is a significant gap between the recommended and currently applied agronomic and water management practices. The problem is related to a lack of appropriate training and resources to enable staff to implement effectively what they have learnt (EU, 2004).

> **Issue/Constraint:** *The poor extension support to irrigated agriculture including the establishment or strengthening of WUAs and SWC works in catchments is a threat to the sustainability of interventions in irrigation (IFAD, 2005).*

Planning, Design and Construction: The prevailing problems in CMI schemes are not associated only to poor extension but also caused by cumulative effects of poor planning and implementation. Many water harvesting and irrigation schemes that are abandoned and/or operating below their expected level (Awulachew, 2005) suffer from faulty designs, poor construction techniques and lack of skill in proper O & M. Shortcomings attributed to capacity limitations at planning stage are very common (IWMI, 2004) such as inadequate estimation of available flows and probability of failure, shortage of water caused by reservoir sedimentation, poor design of hydraulic structures and no measuring facilities, insufficient guidance on system operation, limited explanation to farmers on approach to O&M with farmers believing that government or financing agency would meet the costs and in some schemes pump capacities were not commensurate with the planned irrigable area.

> **Issue/Constraint:** *An assessment conducted in 1999 on 100 irrigation schemes in Oromia region showed that 17% of schemes had failed, 42% performed at less than 50% of their capacity and 41% performed at greater than 50% of their capacity. Problems identified included insufficient collaboration between relevant government institutions having a stake in irrigation, agricultural extension workers were insufficiently qualified and equipped for the complex extension tasks of irrigation agronomy, soil fertility management, crop protection and water users associations were insufficiently trained to manage schemes in a technically, economically and socially sustainable way. Input supply was insufficient (Annen, 2001).*

In Table D.1 below, the main constraints identified for Ethiopian farmers and water production are listed. These derive from the Rapid Baseline Assessment Report as well as information from other relevant sources.

Table D.1 Main Identified Constraints – Ethiopia

	Constraint/Issue	Remarks
A.	**Water Resources Management**	
	Groundwater	Insufficient detailed information available
	Catchment Management	
	Much of the rainwater is wasted as runoff	due to steep slopes, undulating terrain, poor vegetative cover, cultivation in unsuitable areas
	SWC works are implemented in the catchment areas of only some irrigation schemes	Some local guidelines available but no coordination of approach or requirement is established
	Poor choice of Watershed Area	Efforts made on large watersheds (30 – 40,000 ha) had unsatisfactory results due to ineffective community participation, and difficulty in planning/implementing project activities.
B.	**Agricultural production**	
	poverty in the semi arid areas . .	mainly caused by inadequate availability of water for crop, livestock and other enterprises
	Instability of the agricultural growth	Variations in rainfall is a key factor
	Management of Vertisols & insufficient moisture to [illegible]	A primary production constraint is water logging & swelling in the Vertisol areas during the growing season caused by high [illegible] gumes
	[illegible]	[illegible] eld
	[illegible]	[illegible]
	[illegible]	[illegible]
	[illegible]	[illegible]
	[illegible]	[illegible] ng
	[illegible]	[illegible] n view of water resource evaluation, of the assessment of soil and water conservation requirements and of the prevention and resolution of conflicts between user groups
C.	**Extension/Support Services**	
	Availability of water in semi arid areas	A number of best practices relating to land management have been tested in Fatherland Centre and a series of techniques for improving crop production and land management have been documented and are available for extension agents.
	lack of Extension technical capacity in agronomy & water management	Agricultural extension workers were insufficiently qualified and equipped for the complex extension tasks of irrigation agronomy, soil fertility management, crop protection. Master plan studies of Abbay and Tekeze basins also recommended the adoption of conservation based agronomic practices among others
	Significant gap between the recommended and currently applied agronomic and water management practices	Indigenous knowledge is available in some areas for water harvesting, use of drought tolerant and early maturing crops, and state irrigation
	Lack of appropriate extension material for development agents	The extension system, with technical staff at the federal, regional, Wereda and Kebele levels, offers significant opportunity for the dissemination of best practices but lacks comprehensive technical material
	Failure to give full support for the establishment or strengthening of WUAs	
	Extension support to integrated water shed activities is sporadic and uncoordinated	The planning and implementation of integrated water harvesting, soil conservation and other agricultural activities on micro watershed (200 – 500 ha) have been initiated with staff training and preparation of guidelines but extension support is sporadic and uncoordinated.
	Marketing	
	Poor prices received by farmers	poor market linkages and domination of the market by traders who dictate prices to farmers
	oversupply at harvest time & depression of prices	Insufficient advice on planning of crops and staggering of crop planting dates
D.	**Livestock Development**	
	Livestock Productivity Constrained by Water Supply	Capacity building is one of the pillars of the Government's Rural Development policy and strategy
	Lack of suitable pastures	deforestation and overgrazing are persisting problems and major causes of land degradation (resulting from the free movement of livestock in the hilly areas, increasing population pressure, absence of measures to intensify production on existing cultivated land)
E.	**Irrigation development**	
	Poor understanding of water use efficiency	Water use efficiency in irrigation farms close to important markets is higher cash returns are higher from the sale of diversified crops giving more income to invest in technologies and timely maintenance works
	Planning and designs	
	Insufficient understanding of water availability	reduction in planned irrigable area due to shortage of water during periods of low flows, alternative measures were not planned for the periods of low flows;
	Capacity limitations at planning stage	Problems in CMI schemes are also caused by cumulative effects of poor planning and implementation - shortcomings are widespread. For example some schemes pump capacities are not commensurate with the planned irrigable area - no provisions in case of pump failure
	Insufficient understanding of sustainability of planned developments	many water harvesting and irrigation schemes abandoned and/or operating below expected level due to faulty designs, poor construction techniques and lack of skill in proper operation and maintenance
	Water management/distribution services;	
	shortage of water	caused by capacity limitations and the poor distribution of rainwater - leading to short periods of too much water and flooding and long periods of too little water - Moisture stress, caused by prolonged dry spells between rains
	Poor water management in scheme	excessive application of water by farmers situated towards the head of the supply canal (either to grow sugar cane or to over irrigate their plot) resulting in shortage of water by the downstream users resulting from ineffective WUA
	Conflicts between upstream and downstream water users	These are increasing in many parts of the country. New diversions or pumps are being installed upstream of existing diversion weirs resulting in shortage of water for the existing CMI schemes. Farmers are digging shallow wells were close to each other causing poor performance and conflict.
	Lack of measurement devices	no means of measuring the amount of water diverted from the supply canal to the field canals and then to the irrigated field

Table D.1 Main Identified Constraints – Ethiopia (continued)

	Constraint/Issue	Remarks
	Operation and Maintenance	
	Insufficient O&M	farmers reliance on government for maintenance tasks - could have been handled by participating the community at the early stage of the project cycle;
		lack of guidance in irrigation operation and maintenance at local level, either sub district or district level
	Lack of understanding of sustainable O&M	operation and maintenance costs imposed on farmers by an organisation managing the system and not paying sufficient attention to farmer input costs and returns
	Water Users Associations	
	Insufficient attention paid to the establishment and empowerment of WUAs	strong need in all parts of the country - (a) Community based irrigation scheme management; (b) Formation and strengthening of water users' associations; (c) Cooperative management; (d) Crop storage and post harvest handling of various farm products; (e) Administration of saving & credit schemes and revolving funds; (f) Market information management; (g) Monitoring of cooperative marketing; and (h) Construction of cooperative stores.
	WUAs fail to manage schemes	Water users associations were insufficiently trained to manage schemes in a technically, economically and socially sustainable way.
	WUAs byelaws often breached or not observed.	Failure to build upon indigenous irrigation schemes that have unwritten but effective byelaws
F	**Water harvesting**	
	Irregularities of rainfall cause reduction of irrigated land due to shortage of irrigation water in reservoirs and streams/springs	MOARD has established a project office for the coordination of MERET project, which is responsible for the implementation of WH, SWC and capacity building activities focusing on participatory watershed management planning
	Availability of data	Temporal and spatial data that characterize WH and irrigation schemes are often lacking.
	Monitoring & Evaluation	Weak monitoring and evaluation systems have been recognized as a drawback in the implementation of irrigation schemes
	Insufficient learning from experiences	many agencies such as WFP, GTZ, SIDA, IFAD, CIDA and NGOs (such as REST in Tigray and ORDA in Amhara) have been involved in financing capacity building and/or implementation of WH/SSI activities
	Insufficient benefit to upslope communities required to implement SWC	technologies introduced as part of the SWC measure were not observed in bringing a significant economic benefit to the upstream community whose livelihood is connected directly with the catchment areas of the irrigation schemes
	Farmers reliance on single source income	Expected benefit from the existing biological SWC measures, as outlined above, is that 1) the farmers have to wait for a long period before the first harvest and 2) the yield is too low
	Shallow Tillage Depth	Resulting from use of traditional ox drawn plough (widespread existence of a plough-pan in cultivated fields has been concluded as a major limiting factor to increased crop production in Ethiopian Highlands)
	Reliance on Physical structures	proposed and implemented SWC measures comprise mainly physical structures. (Some biological measures and closure of a portion of the catchment from human and livestock interference are also implemented)
	Small scale Storage dams	
	Water tightness of reservoirs/ponds & Canals	Water tightness of reservoirs/ponds and canals is a serious constraint in maximizing productivity per unit of water. Lining o ponds using imported PVC sheet is being used in many parts of Ethiopia, but there are other techniques also in use.
	Sedimentation of storage reservoirs	Shortage of water caused by reservoir sedimentation - could have been averted if the catchment area were addressed as an integral part of the irrigation scheme.
G	**Institutional Aspects**	
	Research-development linkage	
	water tightness of reservoirs/ponds	Research system and some projects have also generated some technologies that would improve water productivity
	Research and Extension Support.	Research and extension support in irrigation water management, irrigation agronomy and marketing is poor or with inadequate coverage
	Integration within the research system and extension system	Integration within the research system (among disciplines and among institutions located in different places) and with the extension system is a persisting problem
	Replication and up-scaling of research findings	Successful practices are limited to pilot project areas or research centres - replication and scaling up of these efforts remains a challenge
	Enabling Policy	Available opportunities, including the enabling policy environment, are not tested fully to their potential
	Legislation for WUA empowerment	Enabling legislations on issues relating to empowering of WUA, cost recovery, operation, maintenance and administration of schemes, water use rights are absent
	Water Charges	There is no legal basis to support the implementation of the water charge
	Organisational Structure supporting irrigation & water harvesting	insufficient collaboration between the relevant government institutions, which have a stake in irrigation and confusion relating to organizational responsibility for WH
	Responsibilities for I&D and WH	Irrigation sector is characterized by frequent restructuring & reorganization (both nationally and within departments) giving loss of institutional learning and experience built up over years.
	Capacity building	
	Lack of adequate training and reference material	Some guidelines are not used as field and district agents complain about the lack of suitable training material & information
	Unstructured capacity training	Upgrading Technical Capacity. Devising and implementing mechanisms for scaling-up of best practices is required. To this effect, training needs assessment has to be conducted regularly followed by the preparation and implementation of appropriate training/skill transfer programs.

ANNEX E – KENYA COUNTRY OVERVIEW

Kenya

The Nile Basin in Kenya covers only 8.5% of the total area of the country but contains over 50% of the national freshwater resources with four major rivers (Nzoia, Yala, Nyando and Sondu Miriu) draining directly in to Lake Victoria[180]. It is distributed within 32 administrative districts and coincides with the Lake Basin Development Authority. Water resources are unevenly distributed across the five main drainage basins[181] of the country varying from 282,600 m^3/ km^2 in the Lake Victoria basin to 21,300 m^3/km^2 in the Athi and Coast catchments. Agriculture is the main user of water and consumes about 80% and this skewed and uneven distribution affects crop production, as there is limited potential for using irrigation to ensure stability of production in dry years[182]. Over reliance on rainfed agriculture contributes to poverty. Kenya has an estimated per capita endowment of 647m^3 per year based on the 2006 population of 31.2 million people.

Issue/Constraint: *Kenya's medium to high potential areas constitutes only 17 % of the total area, with rainfall of at least 700 mm per annum. The rest of the land mass is classified as arid or semi arid. This area requires irrigation for economical farming to be realized.*

Drainage map for Nile Basin in Kenya

Agriculture in Kenya is dominated by smallholdings, covering 46%, of the cultivated area with 92% less than 2 ha (average size is 0.9 ha). This category of farmers[183] experience frequent food shortages in maize, wheat, rice, sugar and edible oils because they are unable to produce enough to meet family nutritional needs. Medium holdings (10 – 60 ha) cover 15% of the cultivated area with large holdings the remainder. Small-scale farming is mainly practiced in the high and medium potential areas[184] and accounts for 75% of the total agricultural output and 70% of the marketed agricultural produce. Small-scale farmers produce over 70% of maize, 65% of coffee, 50% tea, 65% of sugar-cane, 80% of milk, 70% of beef and related products, and almost 100% of the other food crops (millet, sorghum, pulses, vegetables, roots and tubers). The large scale sub sector accounts for 30% of marketed produce comprising tea, coffee, horticultural produce, maize and wheat. The Livestock sub-sector contributes about 10% of the GDP and accounts for over

[180] The Trans Mara River also drains in to the Lake but through Tanzania.
[181] Lake Victoria, 8.0%; Rift valley and inland lakes (22.5%); Athi River and coast (11.5%); Tana River (21.7%); Ewaso Ng'iro (36.3%).
[182] In 2003, irrigated agriculture comprised less than 1.5% of the total agricultural area but contributed more than 3% of the sector's GDP share
[183] 2.9 million farm families
[184] Only 17% is considered as medium and high potential

30% of farm gate value of agricultural commodities. It is a major economic and social activity with intensive dairy production in the high rainfall areas and ranching and pastoralism in the ASALs.

Agriculture is the source of livelihood for 80% of the rural population with women providing 75% of the labour force and contributes 60% of export earnings, 45% of annual Government revenue and produces most of the raw materials for agro-industries. It directly contributes 26% of Gross Domestic Product (GDP) and indirectly a further 27% of GDP through linkages with manufacturing, distribution, and other service-related sectors[185]. In average rainfall years, the country is self sufficient in food. MoA continues to the sector through its strategic plan (covering 2006 – 2012) that involves value addition chain and more emphasis on marketing, development of water ponds, pans and dams to promote farm irrigation systems. It also aims at reducing soil erosion and has set tolerance levels of soil loss of 5 to 10 t/ha/an. to protect and conserve the natural resource base in agricultural areas. Coordination and enforcement of environmental matters are addressed in EMCA and the Forest act. EMCA aims to manage the environment through enforcement of EIA and audits[186]. The Forest service has embarked on a plan to protect and increase forest cover with the relevant institutions dealing with environmental legislation (NEMA, Forest Service) involved in sensitising stakeholders on environmental policies.

Issue/Constraint: *Government extension support has not been widely successful and to address this, the Farmers Field School (FFS) approach was introduced in Western Kenya (Kakamega, Bungoma and Busia) early this century and continues to be used in many areas. It appears to be successful considering the limited number of extension workers and the resources that are available to them.*

Irrigation development is targeted towards improving food and income security of the local people (Water Act[187], EMCA, Forest Act, etc). Kenya has an irrigation potential[188] of 539,000[189] ha out of which 105,800 ha (or 20%) have been developed. 50% of this has been achieved over the last 20 years. Private, public and smallholder categories accounted for 42,800 ha (40%), 16,000 ha (15%) and 47,000 ha (44%) of the total respectively. In the lake Victoria basin, an irrigation potential of 200,000[190] ha has been estimated which is 37% of the national potential. In 1957 some 1,691 hectares of this were under irrigation and by 2003, this had risen to 10,700 ha but this still represents only 5%[191] of the irrigation potential in the area. Public and Private Irrigation schemes in the Kenyan Nile basin include West Kano, Ahero and Bunyala irrigation schemes. Yala swamp development is being undertaken by a private investor called Dominion Farms Limited[192]. Although there has been controversy regarding the environmental impact aspects of the project, it is supporting local communities and the spin off effects are very positive.

Almost all irrigation is achieved through run of river developments although about 4,100 water pans and small dams and 15 large dams have been built the former being located in the arid areas and the latter in the medium potential zones. Basin, furrow and flood irrigation methods are used in most community irrigation schemes with sprinkler and drip being used on some private farms especially for the cultivation of flowers and horticulture crops.

185 Ministry of Agriculture, 2006
186 The National Environmental Management Authority (NEMA) has put in place District Environmental Officers to deal with issues of environmental enforcement.
187 The Water Act 2002 (http://www.water.go.ke/wrma.htm) provides for institutional reforms for implementing the sector's policy objectives.
188 National Water Master plan, 1992
189 The Draft irrigation and drainage policy (2007), revised this up to 1.3 million ha
190 National Water Master Plan, 1992.
191 Compared to the national average of 20%.
192 The government is encouraging such public-private partnerships.

Greenhouses are used by commercial flower growers and also by some small-scale farmers in Kericho and Eldoret. The simple greenhouses are constructed from clear plastic material and are built on to timber structures. They cover on average ¼ acre and are irrigated by drip.

Most irrigation schemes in Kenya are underperforming and as part of the process of improved scheme management and the transfer of responsibilities to users (IMT), government has employed Participatory Rapid Diagnosis and Action planning (PRDA) methodology. This assists in analyzing constraints to performance of an irrigation scheme and generating interventions for improvement together with farmers. Evidence from pilot schemes in West Kano, South West Kano and Awach irrigation schemes showed that the methodology assisted the irrigating farmers to identify various problems facing them and in preparing work plans to address the issues. This involved an increase in capital investment/input, changes to organization and improvement in individual farmer's skills.

Issue/Constraint: *Recent policy documents outline irrigation as a key intervention for food security and income generation - Food Policy Paper (1994); Poverty Reduction Strategy Paper (PRSP 2001); Rural Development Strategy Paper to 2015; Economic Recovery Strategy for Wealth and Employment Creation 2003 –2007; and the Strategy for Revitalization of Agriculture (SRA).*

Shallow wells are becoming increasingly popular with smallholder farmers as a source of irrigation water. When combined with of low-cost water lifting devices like treadle and hand pumps and water-efficient technologies like micro-drip systems, shallow wells have made it practical to carry out micro-irrigation for domestic as well as commercial purposes.

Issue/Constraint: *The biggest constraint is that the wells are rarely designed hence there is a potential for interference with the hydrological systems as well as soil salinization through use of untested saline water.*

A new irrigation and drainage policy has been prepared to create the necessary enabling environment for accelerated irrigation and drainage development and to give recognition to Irrigation Water Users Associations (IWUAs). The Kenya Irrigation and Drainage Association (KIDA) was formed to create networks of irrigation stakeholders and using these organised networks channel information on best technologies and practices to farmers. Recent reforms in the water sector have mandated the WRMA to implement the water policy with regard to management, protection and conservation of water resources through Catchment Area Advisory Committees (CAACs). The Water Resource Users Associations (WRUAs) have been established to involve communities in identifying, quantifying and registering water consumers and to deal with conflict resolution and co-operative management of water resources in the catchments.

Water Harvesting aims to protect the soil surface from the compacting effect of raindrops; allow as much water to enter the soil as is practicable; and ensure drainage of surplus water away while minimising soil erosion risk. This involves appropriate land use, mechanical measures such as earth works and appropriate agronomic practices. Increasing rainfall water use through water harvesting has the potential of increasing agricultural production. Examples of water harvesting activities are found in Nyando district (e.g. Kusa community where RELMA promoted water harvesting and storage and provided 49% subsidy which saw 311 water storage tanks built), Eldoret, Nakuru (in Lare area), Nanyuki (sweet water), Machakos District (Mwala and Utooni). KRHA is an association that brings together water harvesting stakeholders. The department of Land Development in MoA has functions of developing small water harvesting and storage structures.

Issue/Constraint: *There is insufficient adoption of rainwater harvesting for domestic drinking water in rural areas and for backyard crop cultivation from storage. Most affected from the effects of scarce water are women and children who are primarily given the role of fetching water.*

In Part III of the report, sites and schemes that can be considered as possible centres of excellence and that can be used to show good technologies and practices are listed.

Reforms in the water sector will result in addressing water use efficiency and catchment protection. Settling and land degradation has occurred in the Cherengani hills which drain into Nzoi River which feeds Lake Victoria and this is one of the 5 important catchments[193] in Kenya targeted for support. Charges for water use by all sectors will be implemented by WRMA, but more thought needs to be given to the level of charges for agriculture and water harvesting as rates (Table E.1) seem to have been determined from only the potable water supply viewpoint.

Table E.1 Water rates to be used in Kenya

Rates for water use charges for Permit Categories B, C and D.

Type of Water Use	Criteria	Rate
DOMESTIC, PUBLIC, LIVESTOCK	Domestic, public, and livestock purposes	50 cents/m^3
HYDROPOWER GENERATION	Amount of energy generated First 1 MW	 No charge
	Over 1 MW	5 cents per kWh
IRRIGATION	First 300 m^3/day	50 cents/m^3
	Over 300 m^3/day	75 cents/m^3
FISH FARMING	Amount supplied	5 cents/m^3
COMMERCIAL / INDUSTRIAL	First 300 m^3/day	50 cents/ m^3
	Over 300 m^3/day	75cents/ m^3
EFFLUENT DISCHARGE		Nil

Issue/Constraint: *Insufficient thought seems to have been given to the ability of farmers to pay for water charges at the same rate as potable water supplies and the results if the most vulnerable farmers cease to irrigate.*

The major constraints and challenges to accelerated irrigation and drainage development include: (i) Lack of a National Policy; (ii) Legal and Institutional Framework; (iii) Inadequate Public and Private sector Investment in the sector; (iv) Inadequate development of irrigation infrastructure and water storage facilities; (v) Weak Irrigation Water Users' Associations (IWUAs); and (vi) Inadequate support services.

Water harvesting needs to be enhanced in order to cover all aspects of in-situ measures, runoff collection, and storage for homestead, agriculture and drinking water supplies. More attention needs to be given to the involvement of women in the process.

An examination of on-going irrigation and drainage projects in Kenya and especially the Lake Victoria basin needs to be completed to gain full information on the activities taking place and lessons learnt[194]. This needs to include smallholder schemes (e.g. Awach, South West Kano), Public schemes (e.g. West Kano, Ahero, Bunyala) and private schemes (e.g. Dominion farms).

[193] The others are Mt Kenya, Aberdare ranges, Mau hills and Mt. Elgon.
[194] Projects and Programmes in the area are given in Table E.2

Extension services need to encompass more fully both irrigation and water harvesting. Popular approaches that could be introduced in the Kenyan Nile basin include ATIRI, Farmer Field Schools (FFS) and Participatory Rapid Diagnosis and Action Planning (PRDA) methodology. Payment for Environment Services (PES) is a concept that could be piloted in the area in order to sensitize the stakeholders on the benefit that could come with the practice. PES could be introduced in corporation with Water Resource Management Authority.

Issue/Constraint: *Insufficient Extension Services - Farmers need more support in areas of financial management, water management, improvement of agricultural practices and technology, accessibility to inputs and appropriate market outlets.*

International Agreements: Kenya is party to international conventions and agreements including Convention on Biodiversity, Ramsar convention on wetlands and the UN Agenda 21 adopted at the 1992 Earth Summit in Rio de Janeiro, Brazil.

In Table E.2 below, the main constraints identified for Kenyan farmers and water production are listed. These derive from the Rapid Baseline Assessment Report as well as information from other relevant sources.

Table E.2 Projects and Programmes in Nile Basin of Kenya

The Western Kenya Integrated Ecosystem Management Project (WKIEMP)	Aims to improve productivity and sustainability of land use systems in selected watersheds in the Nzoia, Yala and Nyando River basins of Western Kenya that cover about 20,000 km2 with a population of 7 million people. Through adoption of an Integrated Ecosystem Management (IEM) approach, the project will: (i) support on & off-farm conservation strategies through interventions focused on improving soil fertility, agroforestry, and introduction of value added cropping systems; and (ii) improve the capacity of local communities and institutions to identify, formulate and implement IEM activities (including both on & off-farm land use planning) that capture local, national and global environmental benefits. The project aims to reduce poverty, improve food security through better crop yields & diversified agricultural resource base and improve household income. It will also impact on the local economy through development of entrepreneurial activities. At the global level, the project will contribute to the reduction of soil degradation, improvement of biomass production and sequestration of above and below ground carbon. The project will also contribute to reduced siltation, and nutrient runoff to rivers systems draining into Lake Victoria.
Lake Victoria Environmental Management Programme (LVEMP)	Is implemented together with Tanzania and Uganda and focuses on trans-boundary lake management issues and supports on-the-ground watershed management investments that will improve the management of Lake Victoria. ICRAF is part of the technical team for LVEMP II and was involved in the formation of the Lake Victoria Environmental Task Force. Its main objective is to rehabilitate the Lake Victoria ecosystem, using a regional transboundary approach, for the benefit of the inhabitants and national economies. It will address issues of over fishing, eutrophication, algae levels, pollution, and invasive exotic species such as water hyacinth. It commenced in 1994 and is funded by GEF, the International Development Agency (IDA), and national contributions. The follow-up project, Sustainable Management of the Lake Victoria Basin Program (SMLVBP) is under preparation.
National Agricultural and Livestock Extension	Is implemented by MoA and is funded by SIDA. The main objectives are: (I) Participatory monitoring and evaluation of the collaborative activities; (ii) Helping communities in selected focal areas form Common Interest Groups (CIGs) to meet their needs and umbrella committees to link across focal areas; and (iii)

Programme (NALEP)	Testing promising agroforestry, water and land management techniques with farmers.
Kenya Agricultural Productivity Project (KAPP)	Aims are to contribute to sustainable increase of agricultural productivity and improvement of the livelihoods of its rural communities through the development, acquisition and application of improved and profitable agricultural technologies. It is being implemented as 4 components: (i) Agricultural sector institutional reform implemented by KAPP Secretariat. (ii) Extension component implemented by MoA and MLFD will bring input from private and civil society service providers, Universities, commodity organizations, NGOs and private input suppliers interested or able to make a contribution toward improving extension services in Kenya. (iii) Research component implemented by KARI that brings in other research institutes, universities, and private sector organizations interested in agricultural research. (iv) Farmer and client empowerment implemented by District Agricultural Services Units (DSU) at the district level and by the KAPP secretariat at national level. District Client Forums are held to determine organizations that are best placed to deliver specific capacity building interventions at both levels
Agricultural Technology and Information Response Initiative (ATIRI)	Is a participatory research programme implemented by KARI that aims at improving farmers' ability to make demands on agricultural service providers and enhance the effectiveness of intermediary organizations and farmers' groups in meeting the knowledge needs of their clients and members? Unlike in previous research programs, where proposals were developed by scientists, under the ATIRI approach, proposals are formulated by farmers' groups through their CBOs (Community-Based Organizations) who may seek assistance from approved intermediary organizations such as universities and NGOs. All activities focus on the identification, adaptation and promotion of new technologies and methods (new to the participating farmers) as well as preservation and dissemination of Indigenous Technology Knowledge (ITK).
Natural Resource Management Project (NRM)	The Natural Resource Management Project is funded by the World Bank and is implemented by the MWI and the MENR through the Water Resource Management Authority (WRMA), the National Irrigation Board (NIB) and the Kenya Forest Service (KFS). The objectives of the NRM Project are to enhance the institutional capacity to manage water and forest resources, reduce the incidence and severity of water shocks in river catchments, and improve the livelihoods of communities participating in the co-management of water and forests. Achievements under the project will be measured by indicators tracking changes in organizations and their performance, in the health of the natural resource base, and in welfare of participating communities. The NRM Project has four components: Water Resource Management and Irrigation, Management of Forest Resources, Livelihood Investments in the Upper Tana Catchment, and Management and Monitoring and Evaluation. The first two components support the legal and institutional reforms contained in recent legislation, as well as investments in catchment areas. Under the irrigation sub-component, the major public irrigation schemes of Mwea, Bunyala, Perkerra, Adhero and West Kano will be rehabilitated and a new 3500 ha gravity scheme will be developed in the lower Nzoia catchment area. The third component provides assistance to communities participating in management of the resources. The fourth provides managerial oversight and monitoring and evaluation for the project.

Western Kenya Community Driven Development and Flood Mitigation Project (WKCDD/FM)	The objective of the WKCDD/FM project is to empower local communities of men and women to engage in sustainable and wealth creating livelihood activities and reduce their vulnerability to flooding. Progress towards achieving the project development objective (PDO) will be monitored through a set of indicators including: (a) Number of men and women actively participating in decision making at community and district levels; (b) Percent of community and youth investment projects rated satisfactory or better by participating communities; (c) Percentage increase in real income of households in project intervention areas; and (d) Percentage reduction of financial cost induced by average annual flooding in the Budalangi flood plain. The project has three major components as follows: (i) Community Driven Development (CDD). This component will support community prioritized investment projects to improve livelihoods and build demand and capacity for local level development at community and district level. (ii) Flood Mitigation. This component will address four aspects in the Nzoia and Yala River Basins: a) catchment management to address catchment degradation which exacerbates flooding; b) identification and preparation of mid-catchment multipurpose structural flood protection options; c) immediate floodplain management options; and d) establishment of a flood early warning system. (iii) Implementation Support. Through support to research, market assessments, and advocacy work, this component will support the identification and development of new opportunities for economic growth in the region. This component will also fund the establishment and running of key coordination mechanisms in the Office of the President (OP), Ministry of State for Special Programmes.

Table E.3 Main Identified Constraints – Kenya

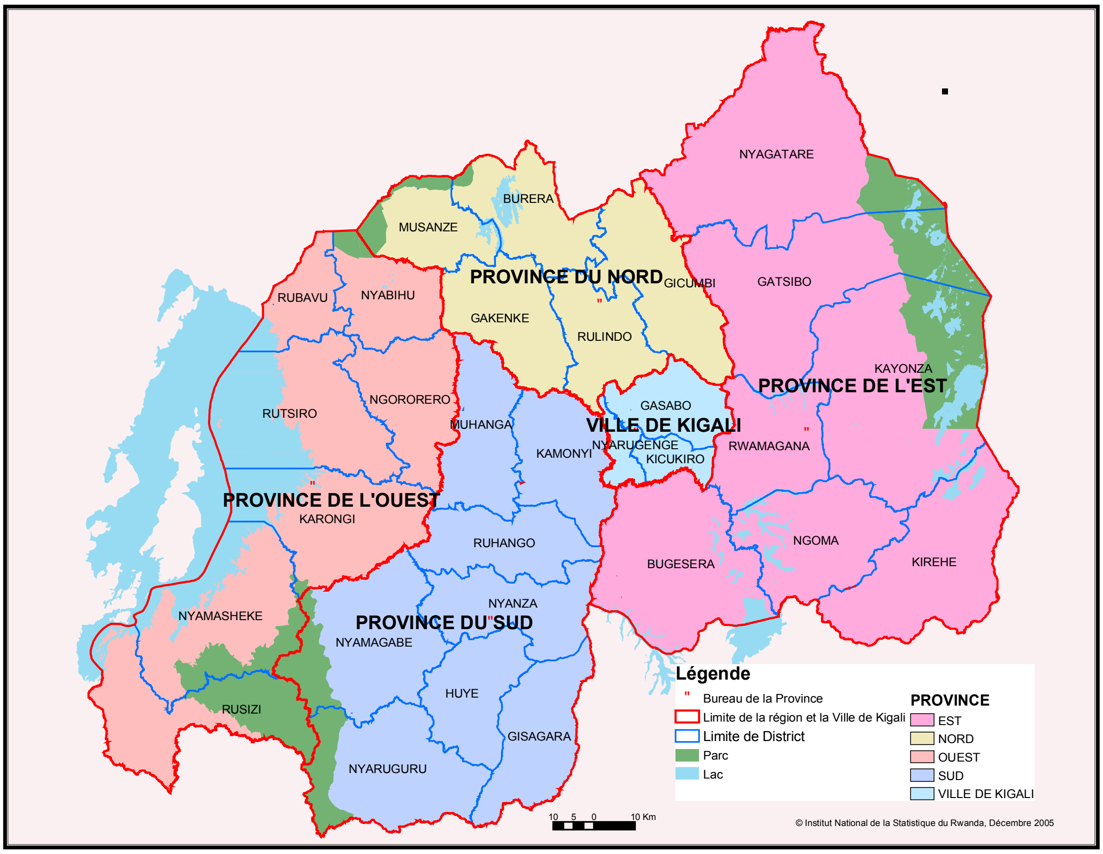
	Constraint/Issue	Remarks
A.	**Water Resources Management**	
	limited natural water endowment	Kenya's currently water endowment is to be 65% of the minimum recommended amount of 1,000m3 per capita and needs to increase efforts to address the challenges of water scarcity mainly through water harvesting, construction of storage and protection of water catchments
	Catchment Management	Deforestation and settlements of catchments have led to heavy soil erosion, loss of biodiversity, and sedimentation of lakes and reservoirs
B.	**Agricultural production**	
	Population pressure on land	Has led to migration to arid and semi arid lands. The migrant farmers tend to use the same farming practices but are faced with low production levels and high risks due to the climate.
		Change of land use takes land from pastoralists who become confined to smaller land areas as their former gazing lands are fenced and farmed.
	Poverty and food insecurity	Between 50% - 70% of population live in absolute poverty with levels in lake Victoria basin being among the highest in
	Poor productivity	high mortality rate from malaria, tuberculosis, typhoid, cholera and AIDS, especially among the people near the lake
	Water pollution.	In Kenya's horticultural areas pollution threats are felt because of over use of agro chemicals. Monitoring of fish for any pesticide residues have not yet yielded any residual levels.
		There is a serious threat of pollution by untreated sewage and industrial waste.
	Poor agronomic and land use practices	Cultivation of steep slopes has led to heavy soil erosion, loss of biodiversity and sedimentation of lakes and reservoirs. The effect of the degradation is seen in increased runoff and flooding tendency (e.g. Nyando and Budalangi areas)
C.	**Extension/Support Services**	
	Farmers slow to adopt production of new crops	Due to inadequate research-extension linkages, farmers continue growing traditional crops such as maize & Irish potatoes despite low incomes realised instead of changing to potential crops such as vanilla, paprika and aloe.
	Insufficient Extension Services	Farmers need more support in areas of financial management, water management, improvement of agricultural practices and technology, accessibility to inputs and appropriate market outlets.
	Small holder farmers obtain free extension services that discourages private extension support	Existing public extension system is targeted towards the smallholder schemes while the private schemes source their experts from the private sector, research institutes and universities
	Marketing	Lack of appropriate marketing channels.
D.	**Livestock Development**	
	Access to traditional migration routes	Fencing off of agricultural land units cuts of migration routes for wild animals and leads to increased conflicts over the
E.	**Irrigation development**	
	Slow development of irrigation	Irrigation development in Kenya is still very low with only 20% of potential developed. This has led to continual reliance on rainfed agriculture contributing to the Country's inability to meet the needs of major food and industrial crops such as sugar, cotton, maize and rice.
	Poor performance of irrigation schemes.	A substantial are performing poorly due to poor system O&M and weak farmers' organizations.
	Low production	Due to the poor irrigation technologies and practices used by the farmers. Experience from IPIA Project has shown by working with farmers to diagnose constraints affecting performance in their schemes and developing action plans to tackle them leads to gradual increase in performance.
	Relative High Cost of Irrigation	Inadequate enabling environment for effective participation in development and financing of irrigation schemes by the public sector, private sector, NGOs and development partners.
	Irrigation of low value crops	Many farmers are growing low value crops that produce insufficient returns to meet the O&M costs and other charges.
	Impact of past support projects is not widely felt.	Whilst there have been significant support from development partners and local NGOs, the impact has not been widely felt. There are several projects and initiatives supported by ICRAF, RELMA, World Bank, IFAD, among others.
	Water Pricing	the requirements to pay for all water regardless of the individual efforts in building water harvesting and storage infrastructure are raising concern among the water harvesting community.
	Poor conveyance efficiencies	Smallholder community irrigation schemes usually use earthed canals for water conveyance which are often subject to high water losses through seepage.
	Water Scarcity by some scheme farmers.	Farmers face water scarcity due to low conveyance efficiencies.
	Problems with pests on SSI schemes.	Limited integrated pest management strategies on irrigation schemes
	Water management/distribution services;	
	Inefficient irrigation methods	Farmers use hand watering, furrows and basins that are not well designed
	Operation and Maintenance	
	High O&M Costs	Due to silting and vegetation growth in earth canals & drains have poor cross sections and insufficient investment in past maintenance.
	Insufficient O&M funds	Due to high defaulting rate and poor enforcement of bylaws.
	Water Users Associations	Insufficient support to farmers to form WUAs
	Current legal status of WUAs is not appropriate	
F.	**Water harvesting**	
	Insufficient adoption of RWH.	For domestic drinking water in rural areas and for backyard crop cultivation from storage.Most affected from the effects of scarce water are women and children who are primarily given the role of fetching water
	Poor distribution of water over the year	There is a growing scarcity of water during the dry season and incidences of flooding during the rains. Most affected are community near the Lake.
	Slow development of Water Harvesting	There are no clear cut interventions by the communities in spite of extension efforts through projects by RELMA in Kusa, Egerton University and KARI in Lare.
G.	**Institutional Aspects**	Lack of enabling environment for the irrigation sector
	Infrastructure	Community based irrigation has limited infrastructural development such as roads and drains.
	Conflicting Mandates	Has caused the slow pace and investment in irrigation development. The irrigation and drainage policy is being developed with the objective of providing coordination and enhancing participation in the sector. This will see further restructuring of MWI to provide for institutions dealing effectively with irrigation development.
		In the past conflicts over mandates have occurred due to overlapping responsibilities: MWI and Regional Development Authorities have both been developing irrigation schemes; MoA and MWI have both been involved in starting smallholder irrigation schemes; MWI and Forest service have undertaken catchment protection and sites for water reservoirs located in the forest; MWI and EMCA have been involved with EIA requirements for smallholder farmers
	Capacity building	Insufficient capacity building of farmers and WUAs.

ANNEX F – RWANDA COUNTRY OVERVIEW

Rwanda

Rwanda is one of the smallest of the Nile Basin countries with most of the country in the Nile Basin (83%) and the remainder in the Congo basin[195]. The country has very undulating terrain with more than 40% at elevations of between 1,500 m and 1,800 m. More than 90% of the national water resources drain to the Nile Basin through the two main rivers of the Nyabarongo and Kagera. Lakes, rivers and marshes cover 212,450 ha (8% of area of the country) of which 128,190 ha comprise the lakes, the largest of which is Lake Kivu covering 102,800 ha. Arable land covers 1,385,000 ha, (52% of the country) with 39% having a high erosion risk . The cultivated area is 852,000 ha (62% of arable land; 31% of the total area of the country). Forest covers 197,000 ha (about 7.5% of the country). In 2000 water use was estimated at 150 million m³/an with agriculture the principal user consuming 68%.

<u>Source</u>: *Francois-X, Dr Ir Naramabuye. December 2007.*



Rwanda is one of the highest populated countries in Africa with an average of 321 persons/km² and 90% of the population are engaged in subsistence agriculture (81% men; 93% women), but production does not meet national food needs. After a long and difficult process of recovery from the genocide, one of the worst atrocities in Africa, Rwanda is now firmly on the path of resurgence and economic development. Since the end of the emergency period, growth rates have averaged 5.8% per annum, making Rwanda one of the top performers in Africa and an example of successful post-conflict reconstruction. The agricultural sector averaged 45% of the GDP in the past decade (1995-2004) and generates nearly 75% of the foreign exchange earnings. Land holdings are small (29% have less than 0.2 ha) and 11.5% of rural households do not own land. Most poor households are located in

[195] Aquastat. FAO. 2005.

rural areas (68%) although significant poverty (23%) occurs in urban area and per capita income veraged US$ 230 in 2004. Due to population growth, the number of Rwandans living in poverty has increased in absolute terms by more than half a million since 2001[196], despite progress in reducing the poverty rates. In order to reduce poverty and initiate the take-off of the economy, Rwanda must break the downward cycle of land fragmentation, over-cultivation and decreasing agricultural productivity, which has locked a large part of the population out of the development process. Poverty, which was estimated at about 77% in 1995, decreased to 60.4% in 2001 and to 56.9% in 2006[197].Only 13% of the population have access to health services and 47% access to potable water. Rural literacy rate stands at 56% for men and 51% for women. In 2002, infantile malnutrition (under-five underweight) was estimated at 24%, with Gikongoro in the Southern Province having as much as 50% and Kibuye (East) and Butare (South) 48%. By 2005, under-five malnutrition had barely decreased to 22% (DHS 2005). Stunting, an indication of chronic malnutrition due to inadequate food or recurrent illness, increased from 43% to 45% between 2000 and 2005 (UNDP; 2007).

Annual rainfall ranges from 800 mm to above 1 600 mm, divided between two rainy seasons (March to May and September to December). The amounts of rainfall, falling in two wet seasons, are good, in most parts of the country, but there is a persistent risk of drought in most areas. The temperature is moderate highland equatorial averaging 16° to 23°C. The country has been divided into 8 agriculture regions depending on crop production, farming systems, staple crops and animals grown. . These include the Volcanoes Highlands, Buberuka North ridges, Buberuka foot ridges, Gikongoro, Lakes Kivu shores, Central plateau, Eastern lowlands and Kibungo.

Table F.1 Agro climatic zones in Rwanda

Parameter	Agro climatic zones of Rwanda		
	High land region	Central Plateau	Eastern Plateau and Western low land
Rainfall (mm/year)	1 300 – 2 000	1 200 – 1 400	700 – 1 400
Number of dry days/an	20-32	50-68	110-140
Temperature (°C)	16 – 17	18 – 21	20 – 24
Evapotranspiration (mm/year)	1 000 – 1 300	1 300 – 1 400	00 – 1 750
Relative Humidity (%)	80 – 95	70 – 80	50 – 70
Runoff coefficient (%)	18	22	10

Source: Rwanda: AQUASTAT 2005

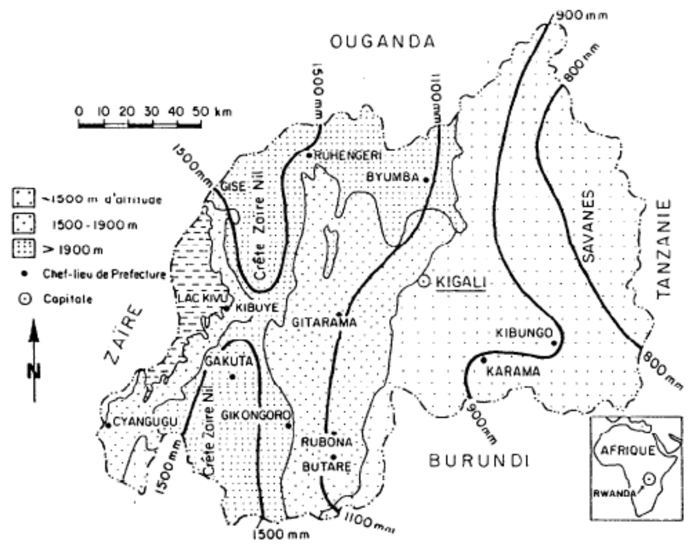
Surface water in Rwanda is mainly defined as lakes and rivers. The hydrological rivers regime is affected by the geographical and temporal rainfall distribution. The important flows are recorded in the great rain season in there are with high precipitation. For the Nile Basin Catchment, the highest river discharge happens during May and April whereas the low water levels take place in August-September. Nevertheless, there is an irregularity more marked in

[196] United Nations Development Programme, National Human Development Report, Rwanda 2007.
[197] The proportion of Rwandans living below the extreme or food poverty line was estimated at 41.6% in 2002 decreased to 36.6% in 2006. Extreme or "food poverty" line is based on the cost of a "food basket" providing 2,500 kcal per adult equivalent per day, using January 2001 constant prices. This poverty line or threshold, below which individuals or households were considered extremely poor, was estimated at Rwf 45,000 in 2001 (Rwf 63,500 in 2006).

the basins of the Congo River where the strongest flows can be observed in November or December. The permanent rivers cover 7.260 ha and the discharge measured at different hydrological stations indicate the following values Nyabarongo at Kigali station : 78 cubic m/s, Nyabarongo at Kanzenze: 100 cubic m/s, Kagera at Rusumo: 232 cubic m/s, Kagera at Kagitumba: 256 cubic m/s.

Lake water has nearly 6% of the total surface of the country that represents approximately 1.500 sq. km of which 65% are occupied by the Rwandan part of the Lake Kivu, in the west of the country. The other 30+ lakes[198] belong to the Nile basin catchment. The Bulera and Ruhondo lakes in the North of the country are relatively deep (~100m) while for the other lakes the depth varies from 5 to 7m and are thus exposed to pollution. . Since 1990, the hydrological monitoring network has changed and only two hydrological stations at Rusumo-Kagera and Butare Bridge on Nyabarongo remain in operation under the support of FAO.

Figure F.1 Agro - ecological zones of Rwanda (Delepierre, 1982)



Drought, floods and landslides are very frequent and the Provinces of the East and South are affected by an alternation of floods and prolonged drought while landslides affect the Northern areas. In late 2001 these damaged more than 2000 ha in the West of the country. Heavy rainfall at the end of January 2007 caused floods that destroyed homes, crops and infrastructure, particularly in southern and eastern regions. The impact was particularly severe in Nyaruguru District, where the rains damaged more than 200 ha and affected an estimated 3535 people.

Water supply depends on springs, shallow aquifers (<60m deep) and the deep wells up to 200m. Spring water is very important in Rwanda as more than 86 % of drinking water is taken from simple protected springs and/or water supply systems using spring water. Those waters are normally of good quality, are often drinkable and can be developed at low cost. Shallow groundwater deriving from rainwater infiltration is generally low in mineralization, but the deep groundwater resources are highly mineralised with a relative high concentration of chlorine[199]. The shallow sources are used to meet the livestock and human needs in the eastern part of the country. Various studies have examined the water table in the volcanic areas and indicate a regular flow of 7.5 - 13 l/s/km² (35,000 m ^{3}/h)[200]. All information on groundwater derived from exploratory drilling is now recorded on a national database developed with assistance of consultants (SHER. 2005). Between 1985 and 1991, 72 wells for water supply were developed in the Eastern Province with 80% still operational. In 1998, LWF installed 58 wells in 5 Districts of the same Province. Since then further projects and organisation have developed wells throughout the country defining the locations through exploratory drilling.

[198] Categorized as lakes of North, Central Plateau, lake Muhazi, lakes of the Bugesera depression, lakes of South-east and lakes of the Kagera national park
[199] SOGREAH 1989, JICA, 1991
[200] TBW Ingénieurs Conseils 1992 ; Igip 2003

Farming is the principal economic activity and is carried out by more than 1.4 million households. In some areas, particularly in the Nile Basin catchment, the population pressure has reduced the area of available arable land per household to about 0.75 ha. Each farm comprises 5 to 6 members, half of them below 15 years of age. 45% of the land area is classified as arable, 18% is rangeland pasture, and 22% is under forest and woodland. About 13% of arable land is under perennial export crops, mainly coffee and tea. A significant production and export of Irish potatoes has arisen in the North and West Provinces in the last few years. Some crops are marketed locally, mainly bananas, which is an important staple food and source of cash income for rural households where export crops are not grown. Beer made from bananas is a major source of income for rural women. Other crops are sorghum, beans, peas, maize, fruit and vegetables. The latter are grown on valley bottoms. Overall, agricultural production and productivity levels are low. Farming systems are risk averse, minimizing the use of capital inputs. Agro-industrial activity is extremely limited, with only some cereal processing and dairy processing.

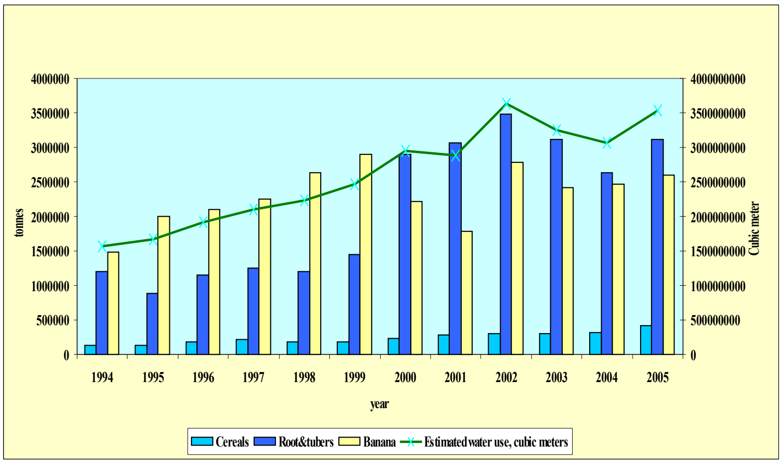
Table F.2 Crop production 1994 -2005

Year	Crop production in tons			
	Cereals	Rice	Root&tubers	Banana
1994	132000		1207000	1489400
1995	141000	2300	881000	2001400
1996	182081	6596	1143004	2105397
1997	211433	9805	1245959	2248419
1998	191226	7935	1204203	2625485
1999	175004	8919	1445638	2897433
2000	235706	11654	2902051	2212250
2001	280702	15610	3070409	1784058
2002	304446	20976	3485214	2784870
2003	294106	28191	3111483	2410537
2004	314943	46190	2639761	2469741
2005	409358	62193	3118050	2593083

Source: Indicateurs de développement du Rwanda, 1999, 2000, 2001, 2002, 2003 et 2004

For most Rwandans, the food regime is 50% tubers, 30% banana and 20% legumes, cereals, vegetables with about 80% of production for home consumption. Prior to 1990s, many households were food secure and had additional cash income. Agriculture takes place on all land types including land of marginal quality and moderate to steep sloping hillsides. To a large extent, soils are fertile and the bimodal rainfall makes two crops a year possible, with a third crop grown in the bottom valley and drained marshlands. Because of the slopes, most land requires soil conservation measures, and manure to prevent the decline of natural fertility. The overexploitation of the land without improvement, the lack of rainwater and watershed management accentuate the erosion process and hence the reduction of crop production. Adverse weather conditions and an increase in most input prices have contributed to food insecurity that remains in 11 of 30 Districts. In Bugesera, many households are food insecure due to poor bean production in 2007. High population densities and poor soil fertility make the Congo-Nile Ridge and the Southern Plateau region chronically food insecure.

The country faces a serious problem of low availability of the cultivable lands with demographic pressure driving soil degradation. More intensive farming and cultivation on steep slopes has increased the incidence of soil loss due to erosion and declining soil fertility. Rwanda’s National Agricultural Commission estimated that half the country’s farmland suffers from moderate to severe erosion.. Currently, the country's food situation has been seriously compromised by the deteriorating natural resources due to population pressure on agricultural land (intensive farming, settlement of returnees in forest zones, fragmentation of farmlands, etc.) and frequent droughts. Over the last years, both production and productivity has fallen for bananas, beans, and the main grains, sorghum and maize. With arable land becoming rarer to find, the people have no other choice but to cultivate areas reclaimed from swamps and steep hillsides, often in an uncontrolled manner. The combination of these factors has speeded up soil degradation and the falling productivity, thus putting the country's food security in jeopardy. In 2004, Rwanda spent more than USD 46 million on food imports[201] and domestic maize production is insufficient to satisfy national demand. Climatic changes leave many rural households vulnerable to food deficits. Hunger is already a chronic problem in some area of the country. The trends in agriculture productivity and estimated water use[202] are given in the figure below.



Livestock production[203] systems are predominantly traditional, although a small number of modern livestock enterprises exist. The breeding contribution to the national economy is still weak in spite of efforts undertaken for the reconstitution after the decimation by the war and the genocide of 1994. It currently contributes 3.7% of the GDP. Sub-sector exports (unprocessed skins) accounts for 2-4% of the country's total exports.

Forestry resources are constantly deteriorating, with the attendant impact on bio-diversity, soil and water conservation. Since the 1994 crisis, the national parks area has reduced from 417,000 ha to 105,000 ha with the Kagera Reserve having lost two-thirds of its size and the Gishwati Forest has almost completely disappeared (from 37,000 ha to 2,000 ha). The forestry sub-sector was estimated to account for 2% of the GDP in 2004 with production estimated at nearly 4 million m^3/annum.

The division of labour for agricultural activity shows that in the 15 to 60 year age group, women devote 30% of their time to domestic chores and 33% to agriculture, compared to men (20% to agriculture and 4% to domestic chores). Men devote 54% of their time to miscellaneous activities and remunerated labour, compared to 18% for women . There are gender divisions of labour and management responsibility in relation to livestock. Men manage cattle and women small stock. Tradition continues to put rural women at a disadvantage in terms of access to land, credit, healthcare and participation in local development decision-making bodies. The cost of healthcare is particularly discouraging to the poor. The disparity is more pronounced at the income and age-group level. The genocide and the war have exacerbated the living condition of women. An estimated 613,000 children below the age of fourteen became orphans after 1994, with the problem further aggravated by the AIDS pandemic. Widows account for 80% of female headed households. In 1999, laws were passed giving equal rights in all areas. Male and female children have equal rights to inherit their parent's property, both prior to, and after, the death of a parent. However, there remain a number of obstacles to effective implementation of the law.

[201] MINAGRI Statistics, 2005
[202] Rwanda and Nile: Water plans and their development 1962-2006. (Baligira Robert, 2007. Unpublished work
[203] Cattle (1,466,573 head of which 7% improved), goats (961,812 head), sheep (380,557 head), pigs (214,701 head), poultry (2,519,568 units) and rabbit (506,927 units).

Fisheries production has been estimated at between 2,000 and 3,500 ton with lake productivity of 40 kg/ha/annum representing 25% of the African average (150 kg) and accounting for 0.3% of the GDP. Production from Lake Kivu is 2,080 tons while other lakes located in the Nile basin produce 1,200 t. Nearly 5,500 artisan fishermen are engaged and the fishing sub-sector is estimated to generate 35 500 jobs.

Issue/Constraint: *The identified constraints of pisciculture development include the lack of qualified technical supervisory staff, an insufficient demand for fish, the expensive construction of ponds, and a lack of clearness as for the objectives of the interventions.*

The Government of Rwanda is engaged in promoting the Agro-business through: (i) commodity chains development, (ii) transformation and competitiveness of agricultural products to facilitate access to markets. The Commodity chain approach constitutes one of the Government's essential axes of intervention methodology and is based on the reinforcement of professionalism, specialisation and regionalisation of agriculture. The promotion of export products as well as the increasing involvement of the private sector has particular importance . Commercial floriculture is a new industry in Rwanda with only one company with 6 ha of greenhouses and 200 employees producing sweetheart roses for export. A new partnership agreement has been established with ESA-EPA, ARPEF to export tax free flowers to the European Union by 2008 they have acquired sites in Bugesera (800 ha) and Ruhengeri-Nyabirande (80 ha).

Irrigation in Rwanda dates back to 1945 when the Belgians built the main Ntaruko – Rubengera canal with 8 km of length to irrigate a small farm. From 1962 to 1994, the total cultivated and irrigated lands were estimated to be 4000 ha. The major part of irrigated lands (8.3% of the estimated potential) are located is in the marsh lands that cover 164,947 ha with around 57% already cultivated with about 13,000 ha currently managed with moderate irrigation structures (regulators, diversions, headworks, etc.). Rice is an important crop and approximately 62,000 tons are produced annually on about 12,000 hectares. Due to the retention of flood flows, the marshlands are important to downstream users as they maintain relatively continuous flow rates in the dry season. The government has developed a Marshland Master Plan framework in which they establish priority crops such as maize, potatoes and beans to reduce the costs of imports. There are also some cases of hillside irrigation which are carried out by pumping systems. Sprinkler irrigation covers 55 ha and drip irrigation 6 ha. A few hectares are irrigated in Ngororero District using spring water and in the Gasabo District with rainwater retained by hillside ditches.

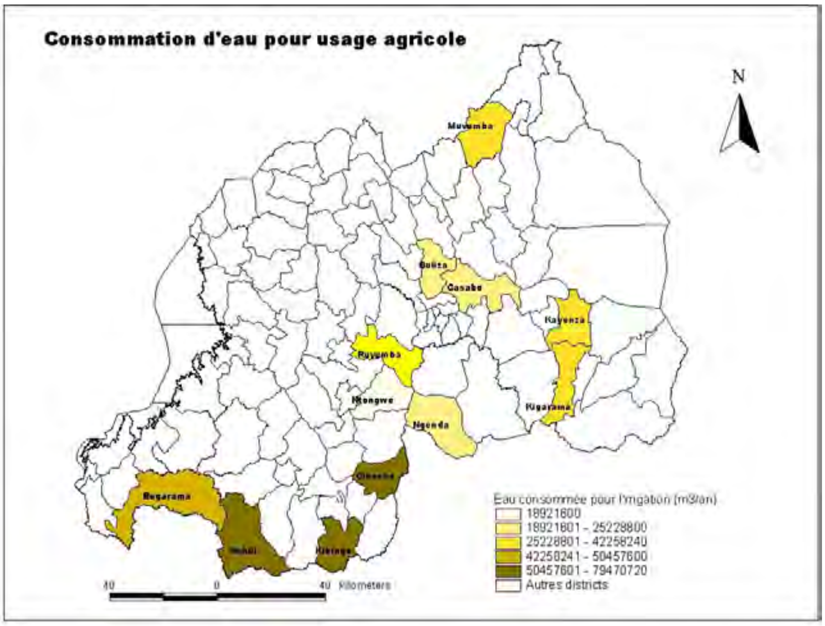
Table F.3 Marshland development for rice crop production

Provinces	Surface area of the Sub catchment ,ha	
	Nile basin	Congo basin
East province	17677	
South Province	36080	
North Province	5616	
Kigali City	2879	
West Province		3841
Total area, ha	**62252**	**3841**

Adapted from: MINAGRI/National rice production programme 2006-2016

The Mwesa Valley irrigation project covers a net area of 650 ha and aims to reduce the impact of drought in Bugesera. Water is pumped from the Nyabarongo River for the double cropping of rice and market-garden crops. Complimentary soil and water conservation to reduce erosion is carried out in the surrounding 5,000 ha catchment. The amount of water pumped varies from 235 l/s in November to 716 l/s in September and represents 1.2% and 0.25 % respectively of the average minimum and maximum flow of the Nyabarongo. The Rome-Kigali Peri-Urban Agriculture Project is a multi-faceted city-to-city cooperation project. The project has involved communities in the management of 500 wetland areas and 1,150 small watersheds; set up 230 local associations on rehabilitated wetlands and 36 in hill areas; established at least 40 micro-gardens, some located in schools for training purposes; and created 96 animal breeding associations and 26 forestry associations. Other small scale irrigation developments include 100 ha of swampland in Ntende/Gatsibo District, Eastern Province, involving riparian communities and a new irrigation project of 240 ha of land along the shores of Lake Cyohoha and in Gashora sector.

Figure F.2 Irrigation water use per District



In rural Kigali Province, in cooperation with various associations, Oxfam Quebec has developed hills into productive terraces, and swamps into cropland, farmed for the benefit of farmer associations. This has promoted access to land and equipped farmers with the techniques needed to combat erosion and soil depletion. Other interventions to bring former abandoned land back into production include the mechanical tillage of land that was formerly part of Kagera Natural Park. This land formerly capped land has led to an increase in household cultivated area by 10%-60%. The use of labour-intensive work to develop marshlands has strengthened the effective participation by beneficiaries and their ownership of the facilities put in place. The Emergency Agricultural Production Recovery Project financed by the ADF obtained remarkable results in terms of impact, sustainability, ownership and participation by the beneficiaries in managing the marshlands developed. Enhanced cooperatives born out of beneficiary associations were involved in all phases of project implementation and are still effective in maintaining the developed marshlands some 4 years after completion.

Rainwater Water Harvesting from roofs using structural storage of 10-50 m³ has been developed for potable and backyard agricultural uses. These have proved successful and the use of RWH for new developments has been made mandatory for Kigali. Other RWH techniques used involved absorption ditches on slopes of less than 20% on deep and permeable soils. These require high labour inputs (200-350 days/ha/an) for construction and 20-50 days/an for maintenance and have not been successful. Terracing is widely pushed to reduce erosion on steep slopes and to permit cultivation of crops. Permeable weirs (grass cords; stones, quickset hedges; earth) have been built to reduce surface runoff and accumulate silt. These have been successful but take time to stabilise. Construction takes is 50-100 person days/ha/an with 10-20 days/an needed for maintenance. In-situ techniques have been sued for a long time and are widely practiced in the form of contoured hedgerows, normally planted with *Pennisetum* species, and grass strips and hedgerows. Because of the time that such measures take and the land that they occupy, farmers often are not keen to undertake the works. Individual farmers, working with extension agents and government officials, have emphasized the use of physical methods (ditches and quickset hedges) as the dominant approach to controlling soil loss and degradation. Terraces and drainage ditches have been constructed in many parts of the country.

The main lessons drawn from various operations in irrigation and water harvesting relate to the project implementation. Centralized decision-making negatively affected the sustainability of achievements. Project implementation units need to work closely with District technical departments and grassroots communities during the project implementation phase to sensitize and organize beneficiaries into associations to establish cooperatives. Project financing should necessarily include provisions to build the capacity of the technical departments. Difficulties were noted with procurement level leading to considerable delays in project implementation. Government has therefore simplified domestic procurement procedures under the new public procurement code and established a National Public Procurements Committee to speed up procedures and ensure compliance with Rwandan rules and donor regulations.

In Table F.4 below, the main constraints identified by farmers and water production are listed. These derive from the Rapid Baseline Assessment Report as well as information from other relevant sources.

Table F.4 Main Identified Constraints – Rwanda

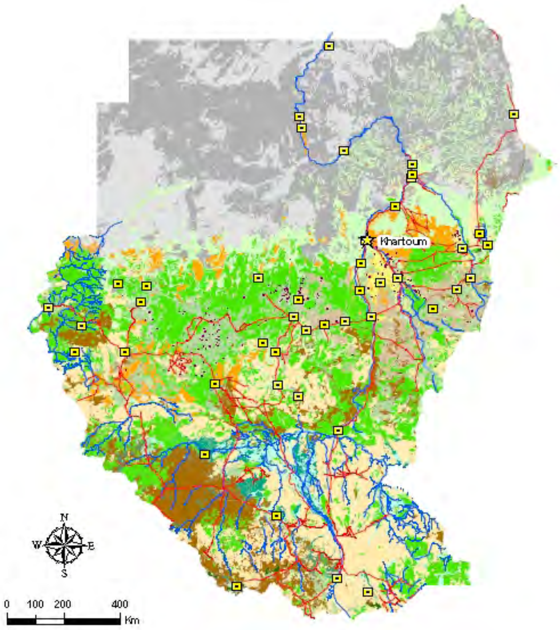
	Constraint/Issue	Remarks
A.	Water Resources Management	
	Groundwater	
	Limited development of groundwater except for local use of springs for both drinking water and agricultural production	Studies were carried out in 1991 and identified potential in the eastern Rwanda; a database giving the results of this study exists having been prepared by consultants in 2005. Water tables are however quite deep, up to 60 m for shallow aquifers, which makes development for irrigation in many cases very costly. deep wells have a high mineral content, especially iodine.
	Most groundwater development and investigations have been aimed at drinking water.	In the early 2000's, a number of organisations developed wells for drinking water, but there has not been a systematic approach or recording of results.
B.	Agricultural production	
	small landholdings and political interference in acquisition	
	Women disadvantaged in their access to resources	
	Poor productivity	
	Shallow soils; poor formation of terraces; acidic soils.	production of cereals, leguminous plants and tubers has reduced in the recent years
	Poor cultivation and land use practices	
	Inadequate coordination of activities on water management .	recent created Soil Fertility and Soil and Water Conservation Initiative (SFI/SWCI) in Rwanda is not yet well established
	Agricultural production	handicapped by weak sectoral organization, inadequate skilled human resources, inexperience of young researchers & limited financial resources
	Moisture availability	In the sufficient moisture on the slopes being cultivated and excessive water in the cultivated marshland areas. Eastern province where rainfall is the lowest is most affected
	Limited use of mineral fertilizers, lime and other fertilizing agents	Current fertilizer consumption stands at 3,500 tons yearly, representing less than 2 kg/farmed hectare, compared to an African average of 11 kg, an Asian average of 51 kg and the recommended average of 150 kg
	Agricultural implements remain rudimentary	All tasks are manual, without the use of animal or mechanical energy
	Shortage of quality seeds	Although there is a high demand especially for rice, cassava, beans, sorghum, potatoes, maize and vegetables, supply is very limited
	Availability & cost of agricultural inputs	Limited availability and high cost of agricultural inputs (especially seed, fertilizer, crop chemicals, and machinery) resulting from poorly developed input distribution systems and exacerbated by high transportation costs
	Management practices	Limited use of land and water management practices that permit sustainable intensification (e.g., irrigation, terracing). Producers' inadequate knowledge of improved management practices
	Physical capacity of work force	Poor capacity resulting from poor nutrition, inadequate rural health services, and widespread prevalence o f debilitating diseases especially HIV/AIDS.
	Farming on very steep slopes	Farming on very steep slopes (50% of fields have a slope gradient above 35%), uncontrolled deforestation, unplanned developments, rapid population growth & shortage of arable land & exposes them to serious erosion; (population density has increased from 143 persons per sq. km in 1970 to 323 persons/km² in 2002)
C.	Extension/Support Services	
	Extension support for WH & I&D	absence of professional and technician in water sector
	Advice on water management	water management for agriculture lacks of skilled staffs
	Markets	
	inadequate transport,	
	Poor and insufficient storage facilities	
	Information system	Absence of an effective information network, traders and other private operators are not well-informed about existing rural marketing opportunities
	Low/variable prices received for outputs	attributable to poorly developed commodity marketing systems and exacerbated by high transportation costs, particularly for regional and international exports
	Finance	
	Access to rural financial services	Lack of access to rural financial services needed to support productive investment in primary production activities as well as post-harvest value-adding activities
	Investment Environment	Unfavourable business climate that discourages private investment by subjecting firms to costly and time consuming regulatory procedures
D.	Livestock Development	
	Livestock feed	Inadequate feed (both quantity and quality); limited and poor pasture; limited use of agricultural by-products;
	Water for livestock	Lack of watering resources in some farming zones;
	Disease	Veterinary services are unable to meet the demands of livestock farmers;
	Forestry	
	Deforestation	forestry overexploitation due to lack of available arable land

Table F.4 Main Identified Constraints – Rwanda (Continued)

	Constraint/Issue	Remarks
E.	**Irrigation development**	
	Insufficient Water control structures	Water control is limited to a few marshlands on which the population has built mostly makeshift structures. Ministry of agriculture estimated that swamps occupy 180751 ha, nearly 12% is used in agriculture production
	Limited use of water harvesting and irrigation	Limited use of water harvesting and irrigation. There is much variability in rainfall across the country and 9 agro-ecological zones.
	Energy	Restricted by high price of the inputs such as fuel and electricity
	Pollution by aquatic plants such as water hyacinth	
	Water Requirements	no clear indication on how much water is used for crop production
	Available data	Limited data available related to water use for agriculture production. Methods of data collection are not standardized. Limited reliable rainfall data collected and analyses are two general.
	Water management/distribution services;	
	MOM	Poor Management and an absence of maintenance of irrigation and drainage facilities
	Involvement of communities in water management	There is a need to empower farmers the skills to solve their own water problems locally to assist them to identify any external assistance they may need, for example sources of credit or technical assistance
F.	**Water harvesting**	
	Technology Uptake	Insufficient knowledge of use of modern irrigation technologies (drip & sprinkler) adapted for hill side, marsh land & low land irrigated agricultural development
	Knowledge of Water Harvesting techniques.	Limited knowledge of possible Water Harvesting techniques. Some programmes have been started by different organisations, but there is no coordinated approach
G.	**Institutional Aspects**	
	Infrastructure	
	Poor maintenance of roads	
	Inadequate coverage of roads in some areas	
	Capacity Building	
	Available Technical Expertise	All government departments have limited skilled and experienced manpower & replacement and training of staff too slow. Main areas of training needed: Irrigation Development, Rural Engineering and Soil Conservation (Water storage reservoirs, weirs, Irrigation & Drainage systems, soil & water conservation techniques, etc)
		Weak human capital base, both in terms of skills attributable to the lack of education opportunities of the rural population, particularly opportunities for vocational training
	Insufficient vocational training	Capacity building is needed at all levels including training, information exchange, technology transfer, active participation supported by provision of suitable equipment.

ANNEX G – SUDAN COUNTRY OVERVIEW

Sudan



Sudan is the largest country in Africa with a total area of about 2.5 million km^2. It has a special geopolitical location connecting the Arab world to Africa south of the Sahara and shares common borders with nine countries[204]. It is divided into 25 states[205] and has an estimated[206] population of 40 million people, 18% of whom live in Southern Sudan, and an annual growth rate of 2.6%. The average density of 14 inhabitants/km^2 masks the fact that about 50% of the population live on just 15% of the land. Most of the population lives along the Nile and its tributaries, and some live around water points scattered around the country. Protracted civil strife and poor economic management has meant that poverty is widespread and predominantly a rural phenomenon with over 2/3 estimated to live on less than US$ 1/day[207]. The economy showed a limited response to reform packages during the 1980s and early 1990s. Budget deficits have been common, annual inflation rates have been high. Interest rates during the late 1990s and early 2000 remained negative and resulted in the collapse of savings, affected the banking system adversely and eroded public confidence.

Although production and export of oil are growing significantly in importance[208], agriculture still remains the major source of income for most of the country's population, 70% of who live in rural areas. In 2004, agriculture contributed over 39% to GDP, employed 57% of the total economically active population and contributed about 90% of the non-oil export earnings (FAO, 2005). Sorghum is the principal crop and livestock, cotton, sesame and groundnuts comprising the major agricultural exports. Millet, wheat, gum Arabic, sugar cane and cassava are also grown. Within the agricultural sector, crop production accounts for 53% of agricultural output, livestock 38% and forestry and fisheries 9%. Industrial development consists mainly of agricultural processing and some light industries. Gold mining is successful especially in eastern Sudan.

Issue/Constraint: *Yields within the country are generally poor with low productivity and low water use efficiency. Extension support needs to be improved in order to realize the full potential.*

The high contribution of livestock production is not recognized by the National and State government, Pastoralists are squeezed out of rangelands to large scale mechanized farming

[204] Eritrea and Ethiopia in the east, Kenya, Uganda and the Democratic Republic of Congo in the south, The Central African Republic, Chad and the Libyan Arab Jamahiriya in the west, and Egypt in the north

[205] Each has its own government and executive and legislative authority. The GOSS administrates ten states.

[206] 2006

[207] The Human Development Index ranks Sudan in 139th place among 177 countries

[208] Extensive oil exploration began in the mid-1970s and exports in 1999 with current production being approximately 500,000 barrels per day.

and traditional farmers are highly neglected despite their role in food security. In central Sudan there has been a major reduction in total area due to desertification and land use changes, which has been exacerbated by widespread deterioration of range lands caused largely by drought climate change and overstocking. This has resulted in less forage and the replacement of palatable for annual perennial grasses by annuals of low environmental and nutritional value.

Issue/Constraint: *There has been limited use of water harvesting for improvement of vegetative cover. Water harvesting and soil treatment are needed for both improvement of vegetation cover (pit planting, contour bunds, water spreading dikes, soil ripping and chiselling) as well as providing appropriate water points for livestock watering.*

There is a high ecological diversity, ranging from desert in the north to high rainfall humid areas in the south. The country is a gently sloping plain with the exception of Jebel Marra, the Red Sea Hills, Nuba Mountains and Imatong Hills. Its main features are the alluvial clay deposits in the central and eastern, the stabilized sand dunes in the western and northern part and the red ironstone soils in the south. Climate is characterised by desert, semi–desert and semi–dry climatic conditions. Annual rainfall ranges from less than 50 mm in the north, 350–800 mm in the central clay plains and savannah belt to more than 1,000 mm in the West Equatorial region in the south. The main rainy or monsoon season is from June to September but the duration will vary with latitude. In the extreme south, there are rainy seasons. The 80% probability of occurrence for the country is given in Table 3.20. Annual evapotranspiration varies from 3,000 mm in the north to 1,700 mm in the south resulting in water deficits for most of the year.

Issue/Constraint: *The high annual variability in crop production relates directly to the unreliable and variable rainfall.*

Available water from all internal and external sources is about 30 bcm (Table G.1) with the Nile and its tributaries that traverse the country for about 9,000 km constituting the main water source[209].

Actual water usage is well below the stated 30 bcm fluctuating between 14 and 18 bcm due to variability in rainfall and flow in the Nile and non-Nile streams coupled with limited available storage capacity[210]. There is still insufficient storage within the country to address this issue and to also assist with overcoming not only periods of drought, but also flood problems. The total storage capacity of Sudan’s four main dams is estimated at 8.73 km^3, reduced to about 6.90 km^3 owing to sedimentation and debris (Table G.2).

Table G.1 Water Resources Availability (Billion Cubic meters)

Water Resources	Quantity (bcm)	Limitations and constraints

[209] Sudan is allocated 18.5 billion m^3/year at Aswan Dam according to the old Nile River Basin Agreement. 64% of the Nile Basin lies within Sudan; 80% of Sudan lies in the Nile Basin.
[210] The raising of Roseires Dam, which is currently underway is expected to improve the situation.

Sudan share from the Nile	20.5	High seasonality, requires storage facilities
Streams (other than the Nile river)	5.5	High seasonality, requires storage facilities
Groundwater	4	High cost for exploration and extraction, plus, requires technology
Present total	**30**	
Potential share from swamp reclamation	6	Environmental
Total	36	

Table G.2 Details of Sudan's Four Main Dams

Dam	River	Capacity (km^3)		Remarks
		Design	Present	
Sennar Dam	Blue Nile	0.93	0.60	For flood control and irrigation of the Gezira Scheme.
Roseires Dam	Blue Nile	3.00	2.20	Plans are in hand to increase the present dam height of 60 m to provide an extra capacity of 4.0 km^3 for flood control and utilize part of the country's share of the Nile waters for irrigation.
Jebel Aulia Dam	White Nile	3.50	3.50	Originally designed to benefit Egypt by augmenting the supply of summer flow to the Aswan dam. After the construction of the High Aswan Dam it was no longer needed by Egypt and was officially handed over to the Sudan in 1977.
El Girba Dam	Atbara River	1.30	0.60	For flood control, irrigation of New Halfa Scheme for the benefit of the people displaced by the High Aswan Dam, and hydropower.
Total		8.73	6.90	

Sedimentation and stream bank erosion are a persistent problem. Silt and debris carried down the Blue Nile and Atbara River have affected the water supply system and reduced reservoir storage facilities. Watershed degradation is one of the major causes and mainly results from the clearance of vast areas of forested lands for cultivation, fuel wood, brick making and fro livestock grazing. Floods and droughts are very familiar in the country and the country faces many local disaster situations each year due to its social and environmental impacts. This problem is most acute on the main Nile downstream from Khartoum. An estimated 17% of 1420 ha in one village (Ganati) and 30% of El Zouma (200 ha) in the Northern State have been swept away with the riverbank erosion leading to sedimentation problem elsewhere.

Issue/Constraint: *National efforts and regional cooperation are required to establish national and regional early warning systems, public preparedness and other disaster management measures. National action is also needed to re-establish the deteriorated natural resource base.*

Actual per capita consumption of water is just over 500 m^3 per year[211], well below the water stress margin of 1,000 m^3 per capita. Agriculture is by far the largest water user with the domestic and industry sectors using around 4%. Future irrigation demand projections prepared in the Long Term Agricultural Strategy estimate a demand of 42.5 bcm by 2027 (Table G.3) or 81% of all water demand. If evaporation from reservoirs for the proposed hydropower development projects is added (6.6 bcm), the total demand will be 59.2 bcm. Water demand according to 25 years strategy is far beyond the available water, even, if the water flowing in the seasonal streams is harvested, the ground water is pumped to its recharge limits.

Table 3.19 Water demand Projection to 2027 (bcm)

Year	Irrigation	Domestic Supply	Animals & Others	Total
2010	27.1	1.1	3.9	32.1
2020	32.6	1.9	5.1	39.6
2025	40.3	2.5	5.3	48.0
2027	42.5	2.8	7.3	52.6

Groundwater is used only in very limited areas, mainly for domestic water supply. Quality is generally good but more investigations are needed. The largest groundwater aquifer, the Nubian Sandstone system, is shared with Chad, the Libyan Arab Jamahiriya and Egypt. Successful pilot projects have been developed in the Northern and Western states with the main constraints for wider development being the cost of exploration, quality, and extraction technology[212]. In some locations due to limitations of resources, remoteness and absence of alternatives only groundwater is available.

Table G.3 Coefficient of Variability of Annual Rainfall by Region

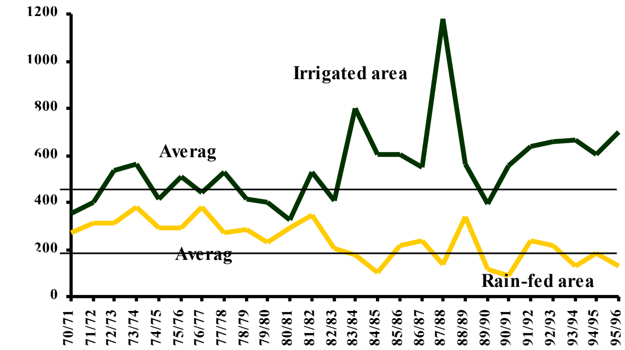
No.	Region	Station	Annual rainfall (mm)			
			Min	Max	Average	80% Prob. of Occurrence
1	Northern	Atbara	0	240	60	20
2	Khartoum	Shambat	3	446	128	40
3	Eastern	Kassala	76	394	215	178
4	Kordofan	El Obied	16	544	318	223
5	Central	Medani	115	504	306	225
6	Darfur	Nyala	197	621	398	297
7	Upper Nile	Malakal	518	1025	732	628

[211] 69% of the population have access to improved drinking water sources (78% in urban areas; 64% in rural regions - displaced families have increased the total population of villages, which has placed pressure on potable water resources.
[212] They extend at depths ranging from 40 to 400 meters and have total dissolved solids ranging from 100 to 2000 PPM

8	Equatoria	Juba	678	1294	973	835
9	B. El Gazal	Wau	733	1429	1075	911

Issue/Constraint: *As with Egypt, more information is needed on the quality of groundwater and the extent of groundwater resources that extend across various Nile basin Counties and the limit of safe development.*

Rainfed agriculture is characterised by the impacts of droughts and floods due to unreliable and variable rainfall (spatial and temporal variability). Only 20% of the 84 million ha. of cultivable land is currently utilized for agriculture, as most of the lands are dependant on rainfall. Traditional rainfed agriculture is practiced on 90% of the total cultivated area and is mostly smallholder farming and agro–pastoral (15 million ha) production. Most of the agricultural activities are concentrated in the centre of the country where average annual rainfall varies from 300-700 mm, in the generally semi-arid dry savannah zone, through which the Blue Nile and the Atbara River flow. The growing season in the region is around four months and the major limiting factor is not the agricultural potential, but the short duration of the rainy season and the erratic distribution of rainfall during the growing period. There is a strong correlation between rainfall amount and productivity with a correlation coefficient of 81%. For the period 1970-96, sorghum productivity per feddan was about 250 kg compared to 750-1000 kg/feddan in the irrigated sector. Local rainfall is the main source of the non-nilotic streams and of the Bahr El Ghazal basin, whereas rainfall over the Central African Plateau (Equatorial Lakes) and over the Ethiopian-Eritrean highlands is the main source of the Nile River system and other transboundary seasonal streams (Gash and Baraka). In the most southern quarter of the country, where the annual rainfall exceeds 700 mm and can go up to 1 600 mm, the area is dominated by extensive wetlands some parts of which are infested by insects which are hazardous to humans and livestock.



Sorghum Productivity Kg/ feddan

About 80% of rangelands[213] are located in semi-desert and low rainfall savannah and these supports a large group of pastoralists and agro-pastoralists. They suffer from a spread in arable agriculture that is taking over rangelands, blocking routes and passage to watering points. Grazing sites and livestock seasonal migration routes need to be efficiently managed to overcome these problems.

Issue/Constraint: *More support is needed to improve ther management of the rangelands and also to improve resources (fire lines construction, enclosures, closing/opening technique, minimizing excessive browsing and grazing, with community involvement).*

Recent agricultural policies have focused on mechanized large-scale rainfed farming achieving increased grain production through expansion of cultivated area and not through yields. The total harvested area increased steadily from 4.5 million ha. in the 1960s to about

[213] Estimated by RPA in 1997 as covering 117 x 106 ha.

20 million ha. in 2000, with great variation of harvested area and total yields. Revealing a fragile balance between production and need, per unit yields of all crops are steadily decreasing with rainfed agriculture seemingly unprofitable and representing an inefficient use of resources.

Issue/Constraint: *There is a lack of perception of conservation and sustainability of resources in rainfed areas with government institutions concentrating on the mechanized rainfed sector to the detriment of the traditional sector (small scale). Environmental implications are a serious decline in soil fertility and deterioration in physical properties where the soil surface is vulnerable to water and wind erosion.*

Wide regional and household deficiency in food security prevails across the country. The most vulnerable areas are the Southern region, North and West Darfur, the Red Sea and North Kordofan States. The food insecurity situation derives from poverty, vagary of low rainfall in many parts of the country, and aggravated by large population movements and displacements that occurred due to the long civil unrest in the south, west and east and to drought in the north, which limit the output of rain–fed agriculture. Agricultural production is practiced under five distinct systems:

Table G.4 Farming Systems Practiced in Sudan

Farming System		Remarks
(i)	Irrigated	Irrigated farming uses mainly surface water. All state owned schemes are under the irrigated sub-system covering about 4.89 million ha. (Including Gezira, Rahad, New halfa and Suki). Average size of holding ranges from 4.2 to 16.8 ha. 1/8 of population involved in agriculture depend on this.
(ii)	Mechanized rainfed	The mechanized or semi-mechanized rain-fed farming, mainly in the central clay plain. Composed of large to medium farm units (about 400 ha). Only land preparation and threshing are done by machines. Comprises about 10,000 large farmers with farm sizes of 400-850 ha and a few large companies with holdings of 8 400-84 000 ha
(iii)	Traditional rainfed	Comprises small holdings and low input agriculture for subsistence and export - no fertilizers are used or chemicals for pest and weed control. 3/4 of population involved in agriculture depend on this. Characterized by a small farm size, labour-intensive cultivation techniques employing hand tools, low input level and poor yields.
(iv)	Flash flood irrigation	Practiced on privately owned land along the Nile and its tributaries. Large scale spate irrigation is practiced in the deltas of Tokar and Gash seasonal rivers. The land which is irrigated once, is enough water to support two consecutive crops
(v)	Livestock raising	Sudan's livestock population of about 120 million heads is managed under nomadic (pastoral), transhumance (agro–pastoral) and sedentary (village–based) systems.

Issue/Constraint: *There is poor adoption of technical packages for production and farmers have insufficient information on crop management packages (improved seeds, fertilizer, pest control, cultural practices, harvest and post-harvest) under both rain-fed and irrigation conditions; and maintenance of soil fertility essential for sustainable production.*

Mechanized rain-fed farming and irrigated agriculture are practiced mainly in the central and southern clay plains comprising mainly Vertisols. These can only be worked under very narrow range of soil moisture and are low in nitrogen and organic carbon and highly prone to water logging due to their very slow permeability. They generally pose a difficult physical environment, but are suitable for production of cotton, sesame, sunflower and sorghum, the stable food of the country (Table G.5). Although these soils have high water holding capacity, the permanent wilting point is very high. In western Sudan, traditional agriculture is practiced mainly on sandy soils that are of low fertility and low water holding capacity. Most of rainfall is thus lost to deep percolation. Gardud soil (sandy/loam soils) is found in extensive areas in Kordofan and Darfur. These have better fertility than sandy soils but have surface seal that reduces water entry in the soil and increase runoff. When this surface crust is broken by tillage, these soils can give good production.

Table G.5 Production of food crops (2006/2007)

Crop	Production (1000 tons)
Sorghum	4,327
Millet	675
Wheat	416
Groundnuts	555
Sesame	400

Total production of cereals on average is around 7.5 million tons annually and annual consumption is around 6.6 million tons. Sudan exports sorghum and imports wheat and rice. Commercial agricultural activities are mostly concentrated in the semi-arid dry savannah in the centre of the country. Small scale subsistence farming is practiced throughout the country but is dominant in Southern Sudan and Darfur. Traditional and mechanized agriculture account for 55% and 45%, respectively but these figures must be treated as indicative as the areas will vary with rainfall. Land degradation in arid and semi-arid regions are a serious problem with sand encroachment into agricultural land and settlements, removal of top soil by wind and water agents, loss of soil fertility, invasive species, riverbank erosion and salinization. Significant mechanized swathes have been deserted because of land degradation.

Issue/Constraint: *Desertification is the most serious problem facing Sudan. This is causing a deterioration of land - the potential capacity of land to produce in a sustainable manner in agriculture, ranges and forests.*

Table G.6 Total arable area by farming sector

Agricultural sector	Area (million ha)
Irrigated	2.254
Mechanized	7.140
Traditional rainfed	3.360

The most salient features of agricultural production in Sudan are low productivity, low value of crops, high fluctuation in areas and low water use efficiency (WUE)[214]. Effective rainfall in

[214] WUE efficiency is calculated as the ratio of economic yield to effective rainfall and/or irrigation.

the clay plain is estimated as 75% of rainfall or 80% in irrigated agriculture occurring after sowing and 60% in the sandy soils.

Irrigation Development: Sudan has the largest irrigated area in sub-Saharan Africa and the second largest in all Africa, after Egypt. The irrigated sub-sector contributes more than half of the total volume of the agricultural production although the irrigated area constitutes only about 11% of the total cultivated land. It has become more and more important over the past few decades as a result of drought and rainfall variability and uncertainty. The irrigated sector produces 95% of the long stable high quality cotton produced, 100% of sugar production, 36% of sorghum and 32% of groundnuts. Other main irrigated crops are fodder, wheat and vegetables with other crops comprising maize, sunflower, potatoes, roots and tubers and rice. Although irrigated agriculture started more than 100 years ago, water productivity is very low, not exceeding 0.2 kg/m^3 for the major rotational crops (cotton, sorghum, ground nuts and wheat). This is attributed to water not delivered at the right time in the right quantity due to poor canal condition (silting, aquatic weeds) and poor management of irrigation water at the field level.

Irrigated agriculture falls into two broad categories: traditional and modern schemes. Traditional irrigation is practiced on the floodplains of the main Nile downstream of Khartoum and on substantial areas along the Blue and White Nile, and the Atbara river as well as on the Gash and Tokar deltas. Many schemes are fully equipped with infrastructure but have low cropping intensity due to scarcity of water during the long dry season. Large-scale gravity irrigation started more than 100 years ago and was characterized by the promotion of cotton production in the Nile Basin. Irrigation by pumping water began at the beginning of the 20th Century, substituting traditional flood irrigation and water wheel techniques. The Gezira Scheme is Sudan’s oldest and largest gravity irrigation system, located between the Blue Nile and the White Nile. Started in 1925 and progressively expanded thereafter, it covers about 880 000 ha. receiving water from the Sennar Dam on the Blue Nile and is divided into some 114 000 tenancies. Farmers operate the scheme in partnership with government and the Sudan Gezira Board, which provides administration, credit and marketing services. The scheme has played an important role in the economic development of Sudan, serving as a major source of foreign exchange earnings and of Government revenue. It has also contributed to national food security and in generating a livelihood for the 2.7 million people who now live in the command area of the scheme. After independence, irrigation development continued with large scale irrigation schemes and this was encouraged by the increase in Nile water allocation through the 1959 Nile Waters Agreement with Egypt. In the 1970s, large investments were received from oil-rich Gulf nations and large-scale irrigated agriculture expanded from 1.17 million ha in 1956 to more than 1.68 million ha by 1977. The 1980s were a period of rehabilitation, with efforts to improve the performance of the irrigation sub-sector, and in the 1990s some smaller schemes were licensed to the private sector.

In 2000, the total area equipped for irrigation was 1,863,000 ha, comprising 1,730,970 ha equipped for full or partial control irrigation and 132,030 ha equipped for spate irrigation. Out of the estimated irrigation potential area of 2.8 million ha[215] about 70% (1.9 x 10^6 ha.) is currently irrigated mainly on 4 large government–owned irrigation schemes plus a number of small–irrigated schemes along the Blue and White Nile Rivers[216]. Only about 800,000 ha, or 43% of the total area are actually irrigated owing to deterioration of irrigation and drainage infrastructure. Surface water supplies 96% of total irrigated area with the remaining 4% being irrigated from groundwater (small tube-wells). The irrigated area where pumps are used to lift water was 346,680 ha in 2000. Most irrigation schemes are large-scale and they are managed

[215] This does not include possible large-scale developments in the enormous wetlands in southern Sudan

[216] In 2005, only half was actually cultivated, owing to dilapidated irrigation and drainage structures and canal siltation.

by Parastatals (Agricultural Corporations) while small-scale schemes are owned and operated by individuals or cooperatives.

Issue/Constraint: *The condition of the irrigation and drainage infrastructure has deteriorated badly due to insufficient past investment and a lack of involvement of the beneficiary farmers in the operation and maintenance of the systems that they use. More emphasis is needed on formation of users associations, local community advisers and extension services.*

About 14.6 bcm of annual water resources are currently used for irrigation and about 1.3 bcm of underground reserve are utilized mainly for domestic purposes and limited irrigation activities. Water demand according to the 25 year strategy is far beyond the available water; even if the water flowing in the seasonal streams is harvested and the ground water is pumped to its recharge limits.

A study undertaken in the Rahad Scheme based on data from 1977 to 1995 shows that actual crop yields are well below potential yields and that overall efficiency is between 63-68%. The distribution efficiency of the network was 93% and estimated field losses were 25-30%. In the Gezira Scheme, a complex mix of financial, technical and institutional problems resulted in a serious fall in the productivity and a corresponding drop in farm incomes and cropping intensity from 80% in 1991/92 to 40% in 1998/99. About 126,000 ha were taken out of production owing to siltation and water mismanagement, leading to a reduced availability of water (water supply was about 12% below crop water requirements at crucial stages in the growth cycle and 30% of the water delivered was not used by the crops). However, an initiative aimed at “Broadening farmer’s choices on farm systems and water management” by FAO increased productivity of sorghum, cotton and wheat to 112% by 2000/01, compared to the Gezira average of 42%.

Issue/Constraint: *Insufficient experience of irrigators and farmers in irrigation water control and water harvesting and conservation techniques. Poor water management techniques are used by many farmers at the moment and there is a need for farmers and water utilization agencies to be advised on best practices and to become familiar with the optimum quantities of water to be used for their needs.*

Apart from the Gezira scheme established in 1925, most of the irrigation schemes were developed in the 1960s and 1970s. Since then, there have been no significant irrigation developments, for two reasons: any possible remaining sites would be complex and expensive to develop, and the low levels of productivity of the irrigated crops in the country make it difficult to justify further investment. Thus, to meet an ever-increasing demand for food and fibre, priority has been given to increasing productivity from existing irrigation schemes.

The Eastern Region is among the most vulnerable drought–prone areas in the country and received emergency assistance over many years. Agriculture is traditional and subsistence in nature and forms the main source of livelihood for the majority of population. The land use pattern in this area evolves around animal herding, small–scale traditional cultivation, limited drinking and irrigated ground water holdings and flood basin irrigation with traditional dryland farming and animal herding representing the two major land uses in the region. These form the economic basis for survival and adaptation to the prevailing harsh environmental conditions to large group sectors of population. With exception of Tokar and El Gash deltas, where agriculture is more reliable, crop production in the region is practiced under conditions of high risks and uncertainties. The average cultivated area is very small (0.5–4.0 ha per farm), and crops are subjected to surface runoff water limitation and rainfall uncertainty. Thus, cereal production usually falls short of the total household consumption needs; the farmer depends primarily on food aid and on grains purchased from local market.

Issue/Constraint: *Major constraints to higher farm productivity and incomes are high marketing margins on agricultural produce and an inadequate allocation of budgetary resources and of the scarce foreign exchange earnings. As a result, the low input/ low-productivity model of production continues to prevail, and small farmers' incomes remain depressed.*

In the wake of the food shortages experienced in the 1980s, high priority has been given to producing food crops. This has resulted in large expansions in sorghum and wheat areas and output, but at the expense of the main cash crop, cotton, with production declining by more than 40% since then.

Water Harvesting is an indigenous technique in parts of the country for drinking water supply in rural areas and for crop production under spate irrigation. A number of water harvesting projects concerned with harnessing surface runoff for provision of domestic and stock drinking water to combat the effects of drought by improving crop production and increasing domestic water use was implemented in western Sudan between 1970s and late 1990s. However, few have succeeded in combining technical efficiency with low cost and acceptability to the local agro-pastoralist farmers. This is partially due to the lack of technical know–how, but also because of the selection of inappropriate approaches with regard to the prevailing socio-economic conditions.

Issue/Constraint: *There has been limited adoption of water harvesting techniques for improving and conserving water. Much more support required to farmers to advise them on possibilities for water harvesting and benefits that can be achieved.*

In the Eastern Region, rural water supply ranks as one of the top priorities both from social and economic welfare. As a result of severe climate changes, mainly low rainfall, land degradation, declining agricultural production together with loss of livestock, a number of different types of water supply systems were developed. These include the traditional water system (natural water pools and depressions), deep bore–holes equipped with motorized pumps (water yards), hand–dug open shaft wells, slim bore–holes fitted with hand– pumps, privates cisterns (*khazanat*) in towns and surface water structures (*hafirs* and dams).

Spate irrigation is practiced mainly in the Red Sea and North Kassala Regions (Gash, Tokar and Abu Habil) developing the network of seasonal watercourses and streams. The loamy and alluvial deposits found in these areas, offer good grazing for livestock and rainfed farming using spate and flood residual moisture during the rainy season. In Darfur State, water harvesting is also practised using masonry control structures to divert flood water via distributory canals to irrigate agricultural land. Silt build-up over the years present problems in all spate systems and contribute to the high annual O&M costs of these systems. The major other problems facing this sector are sand dune encroachment, riverbank erosion and invasive weeds (UNEP, 2007).

Issue/Constraint: *The successful experiences obtained over the years in areas like Kessala must be applied to other parts of the country. Annual accumulation of silt in channels results in very high costs in O&M budget and thus designs must accommodate measures that permit a reduction in the amounts of sediment entering headworks and main canals.*

Financing irrigation O&M through fees collected from irrigation system beneficiaries was first introduced in 1909 but failed after 2 seasons when farmers were unable to pay due to a poor crop harvest. This experience was used in the Gezira scheme and to avoid the inability of some farmers to pay irrigation fees in case of bad crop yields, a "sharing system" between the three parties was adopted. This continued until 1981 when it was replaced by "individual account system" in which each individual farmer is treated separately in terms of cost and profit creating an incentive for the individual farmers to increase their productivity. The new account system failed to achieve break-even productivity from 1981 to 1995 and during this period irrigation fees collected averaged at about 50%, with government meeting the balance of the costs. Starting from 1995, Government withdrew from financing the cost of irrigation services, and farmers were left to pay irrigation fees to the newly established Irrigation Water Corporation (IWC), which uses these fees directly to provide water supply services to the farmers. IWC relied on Agricultural Corporations (AC) managing the scheme to collect the fees from the farmers and because these ACs were facing considerable financial difficulties, part of the water fees collected did not reach the IWC. This led to the accumulation of deferred maintenance with sediment not removed from irrigation canals, deterioration of the water regulation structures, machinery and pumps. By the year 2000 the IWC was dissolved and the MIWR was again responsible for O&M of irrigation canals down to the minor off-takes.

Issue/Constraint: *Many of the irrigation and drainage systems in the country are in a poor condition. More effort is required to ensure that effective WUAs are established and that they are trained and able to take over much of the O&M of the systems with charges levied related to the ability of the farmers to pay.*

Water management: Sudan experience in community based water management has been limited to small irrigated schemes along the Nile. Water users associations were elected in the Gezira Scheme with little success and it was evident that the farmers did not receive enough training on water management. To address some of the problems facing irrigation management and development, Government has formalized a policy framework that includes (i) transferring O&M of large/medium-size irrigation schemes to the farmers and giving them full responsibility for water management below the minor canals level through establishment of voluntary water users associations (WUAs); (ii) Fostering sustainable productivity of the large schemes through rehabilitation, combined with financial and institutional reform; (iii) Grouping, rehabilitating and handing over the relatively small size pump schemes in the Blue Nile and the White Nile. These schemes were originally established and run by the government. Recently, and in accordance with the economic reforms, these schemes were handed over to the private sector represented by individual farmers, cooperatives or private companies.

Issue/Constraint: *Lessons learnt in neighbouring countries in the establishment and involvement of the farmers in the WUAs and their empowerment. Farmers must be involved to a much higher degree so that they regard the systems as theirs. This should be carried out at the appropriate level, so that unjustified assumptions on their ability and and willingness to take over the system are not made.*

The major constraints to irrigation development include ineffective process of annual maintenance of civil works (reportedly due to lack of funds), especially for the removal of silt and weeds from irrigation canals; the steady increase in development costs, which has been aggravated by the continuous devaluation of the local currency; the lack of farmer involvement in the planning and operation of the schemes and related services. Water utilization efficiency is very low and farmers must be educated and become familiar with the optimum quantities of water to be used for their needs. Raising the awareness of stakeholders and their participation is the basic requirement for enabling the beneficiaries to sustain and maintain productivity. Stakeholders should feel that the system belongs to them. This should be emphasized through formation of users associations, local community advisers and extension services. The long term agricultural strategy should emphasize more production with less water in the irrigated sector. Adoption of technical packages of production as released from ARC is a prerequisite for high water use efficiency. This needs an extensive extension programme, provision of high yielding varieties etc.

Issue/Constraint: *The Extension/Support Services to irrigated areas needs to be significantly improved to ensure that good and appropriate advice is provided and that the poorer and resource poor farmers are given better support.*

In Table G.7 below, more details on the identified constraints are presented. These derive from the Rapid Baseline Assessment reports and also experiences of donor and other agencies.

Table G.7 Main Identified Constraints – Sudan

	Constraint/Issue	Remarks
A.	**Water Resources Management**	
	Floods and Droughts	Nation efforts and regional cooperation are required to establish national and regional early warning systems, public preparedness and other disaster management measures
	deterioration in natural resources base	Due to desertification and watershed degradation.
	Catchment Management	Existing information on watershed degradation in Sudan are mostly qualitative, descriptive and/or very theoretical in nature
	Watershed Degradation and Sedimentation:	Silt deposition in the Blue Nile and Atbara Rivers has interfered with their flow regimes.
	Watershed degradation	mainly resulted form the clearance of vast areas of forested lands for cultivation, fuel wood, brick making, and over grazing.
	Bank erosion along the rivers has contributed to increased sedimentation elsewhere.	Silt and debris carried down the Blue Nile and Atbara River have affected the water supply system especially the limited reservoir storage facilities.
		Riverbank erosion is a natural phenomenon in Sudan that can be characterized, in extreme cases as a local disaster due to its social and environmental impacts. This problem is most acute on the main Nile downstream from Khartoum. An estimated 17% of 1420 ha in one village (Ganati) and 30% of El Zouma (200 ha) in the Northern State have been swept away. Riverbank erosion lead to sedimentation problem elsewhere
	Desertification	Desertification is the most serious problem facing Sudan. This is causing a deterioration of land - the potential capacity of land to produce in a sustainable manner in agriculture, ranges and forests.
B.	**Agricultural production**	
	High annual variability in areas depending on rainfall.	Low value of crops, Low productivity, Low water use efficiency.
	Insufficient appropriate inputs and crop varieties	Farmers do not have enough advice on new crops, crop rotation, organic farming, farm plots protection shelterbelts, selection of improved crop varieties (cereal, legumes, forage, vegetables and fruit trees).
	Low productivity	Agricultural Research Corporation (ARC) lists the following reasons as major causes : Poor land preparation; Very late sowing; Use of low yielding varieties; Poor disease and pest control; Use nil or minimal fertilizer; Poor management of irrigation water; Narrow cropping system
	Poor adoption of technical packages for production as released from ARC.	Insufficient information on crop management packages (improved seeds, fertilizer, pest control, cultural practices, harvest and post-harvest) under both rain-fed and irrigation conditions; and maintenance of soil fertility essential for sustainable production.
	The same yields realized now could be obtained by less than one fourth of the water consumed.	
	Land degradation	The most serious forms of land degradation in arid and semi-arid regions of Sudan are sand encroachment into agricultural land and settlements, removal of top soil by wind and water agents, loss of soil fertility, invasive species, riverbank erosion and salinization.
C.	**Extension/Support Services**	Inadequate extension services to reach many of the poorer and needy farmers.
	Marketing	
	Low Market Prices	Prices of sorghum are low and in many cases farmers fail to pay back their loans because of the low productivity obtained especially under rainfed conditions. Low yields are mainly caused by low yielding varieties, delayed sowing and spread of weeds
	Finance	
	Finance of the agricultural sector	Most farmers are unable to meet the collateral requirement of the financial institutions which include for example, fixed assets, guarantors. It is not uncommon for banks to require collateral up to three times of the value of the loan amount. Many mechanized rainfed farmers were unable to repay the loans in bad seasons and are prosecuted
	No or little access to credit.	Many disadvantaged traditional farmers cannot access credit due to their inability to provide co-operative guarantees or personal guarantees acceptable to banks. Banks are unaccustomed to working with the poor and see it as inherently risky. Increased credit access remains a key to poverty alleviation strategy in rural areas.
	Effective annual rates of interest are often higher than the formal sources of finance	Informal sources currently provide for most of the financial needs of the poor. Rich farmers usually extend loans to poorer landowners and tenants in exchange for part of their yields. At times, money lenders, shopkeepers, middlemen also provide credit.
D.	**Livestock Development**	
	Range land degradation due to overgrazing resulting from overstocking.	this has resulted in less forage and the replacement of palatable for annual perennial grasses by annuals of low environmental and nutritional value.
		In central Sudan there has been a major reduction in total area due to desertification and land use changes, which has been exacerbated by widespread deterioration of range lands caused largely by drought climate change and overstocking
	Support to Livestock	High contribution of livestock production not recognized by the National and State government, Pastoralists are squeezed out of rangelands to large scale mechanized farming, traditional farmers are highly neglected despite their role in food security.
	Poor range management	Range husbandry and grass quality preservation improvement techniques are needed
	Inadequate protection and management of vegetation cover	Needs to provide more support for resources (fire lines construction, enclosures, closing/opening technique, minimizing excessive browsing and grazing, with community involvement);
	Limited use of water harvesting for improvement of vegetative cover.	Water harvesting and soil treatment required for vegetation cover improvement (pit planting, contour bunds, water spreading dikes, soil ripping and chiselling); and
	Improved processing of livestock by-products.	
	Poor awareness by farmers	Insufficient awareness by stakeholders of factors involved in improving and maintaining productivity.
	Poor adherence to recommended rotation for the irrigated and the rainfed sectors.	The current practices lead to loss of soil fertility, intensification of the weed problem (especially striga), loss of soil fertility, deterioration of soil physical properties and excessive wind and water erosion.

Table G.7 Main Identified Constraints – Sudan (Continued)

	Constraint/Issue	Remarks
E.	**Irrigation development**	
	Inefficient water management at the field level	Inadequate number of trained staff with limited skills in the efficient and effective management of water.
		Insufficient experience in irrigation scheduling, methods and practices.
	Insufficient irrigation facilities and storage	
	Slow adoption of technical packages.	Insufficient experience of irrigators and farmers in irrigation water control and water harvesting and conservation techniques
	Poor water management techniques	Farmers and water utilization agencies must be educated and become familiar with the optimum quantities of water to be used for their needs.
	Stakeholders do not feel that the system belongs to them.	More emphasis is needed on formation of users associations, local community advisers and extension services.
	Poor adoption of technical packages for production as released from ARC.	Current extension packages do not emphasize sufficiently the need for more production with less water in the irrigated sector.
F.	**Water harvesting**	
	Limited adoption of water harvesting techniques for improving and conserving water.	Much more support required to farmers to advise them on possibilities for water harvesting and benefits that can be achieved.
	Small scale Storage dams	Sedimentation of reservoirs.
	Spate Irrigation	rise in river bed causing continuous changes of the River alignment and bypassing offtakes and damage to adjacent areas
	High annual O&M costs	annual accumulation of silt in channels results in very high costs in O&M budget
	Siltation of canals	which directly affects canal capacity and increases substantially the operation and maintenance costs
	Deposition on transported material on land	Continuous raising in the level of agricultural land with the resultant reduction in command
	Increase in bed levels of seasonal rivers	Gradual raising in riverbed levels due to accumulation of transported material resulting in more frequent overtopping by
	Inefficient designs for spate diversion structures	Limited support to farmers to advise them on improvements to retention and water spreading dikes on Wadis' beds;
G.	**Institutional Aspects**	
	Inadequate coordination among water related sectors	Essential for developing an integrated holistic approach needed for sustainable water resources management
	Research-development linkage	Poor linkages between research, education and development
	Poor awareness of all stake holders about the scarcity of water and the need for efficient use to maximize returns from water.	Research is under funded and researchers need more training in specialized institutes.
	Capacity building	
	There are no specialized courses in water management issues.	Institutes and NGOs involved in the Water Sector: Agricultural Research Corporation, Ministry of Science and Technology; Forestry National Corporation; Higher Council for Environment; Hydraulic Research Station; Institute of Irrigation and Water Management, University of Gezira; Ministry of Agriculture; Ministry of Animal Wealth; Ministry of Environment; Ministry of Health; Ministry of Irrigation and Water Resources; State Ministries of Agriculture, Animal Wealth and Irrigation; Sudanese Society for Community Tree Planting (NGO); Sudanese Society for Environmental Protection (NGO); UNISCO Chair in Desertification; UNISCO Chair in Water Resources; University Of Khartoum
	Specialized extension in water management issues is lacking	
	institutes in the water sector are under funded and lack equipment and trained staff.	
	Insufficient capacity for water management in the country	Water resource monitoring, assessment and development is divided among many institutions. Similarly water use is managed by different sectors.
	Limited capacity for the design and implementation of irrigation and water harvesting projects	

ANNEX H – TANZANIA COUNTRY OVERVIEW

Tanzania

Tanzania, with a 2005 population of 38.3 million[217] and a land area of 945,100 km^2 is the largest country in Eastern Africa and has enjoyed relative political stability since independence. Agriculture is the leading sector of the economy of Tanzania, despite the rapid growth of mining, and has maintained a steady growth rate of over 3% p.a. over the last decade and accounts for more than 50% of the GDP[218] and export earnings[219]. It has linkages with the non-farm sector through agro-processing, consumption and export; provides raw materials to industries and a market for manufactured goods. About 80% of the population live in rural areas and earn their living mainly from agriculture and in spite of this reasonable growth, the livelihood of the rural population remains unchanged. This has often resulted in localized food insecurity and hunger, which has been exacerbated by the lack of access to external resources by households.

Lake Victoria Basin lies within the Nile Basin in Tanzania. It comprises the 4 regions of Kagera, Mara, Mwanza and Shinyanga, the last three of which are famous for cattle rearing and are major growers of cotton with coffee introduced in Mara quite recently. Kagera region is characterized by banana/coffee/horticulture system. Other crops grown in the basin include maize, rice, sugar, tea and horticultural products (See Table H.1 below) with agricultural activities involving an estimated 75 % of the workforce.

Table H.1 Details of Farming Systems

Farming System	Regions	Remarks/Other Crops
Banana/coffee/ horticulture	**Kagera**, Kilimanjaro, Arusha, Kigoma and Mbeya	In some of these areas this system is intercropped with beans and groundnuts.
Maize/legume	Rukwa, Ruvuma, Arusha, **Kagera**, **Shinyanga**, Iringa, Mbeya, Kigoma, Tabora, Tanga, Morogoro, Kahama, Biharamulo	In some of these areas this system is intercropped with beans and groundnuts.
Cashew/coconut/ cassava	coast region; eastern Lindi and Mtwara	
Rice/sugar cane	Found in alluvial river valleys and plains	
Sorghum/bulrush millet/livestock	Sukumaland, i.e. Shinyanga and Rural Mwanza	Other crops grown under this system include maize, cotton, oilseeds and rice.
Tea/maize/pyrethrum	Njombe and Mufindi districts in Iringa region	The system also includes irish potatoes, beans, wheat, wattle trees and sunflower.

[217] Projected to rise to 49.3 million by 2020.
[218] Agricultural GDP has grown at 3.3% p.a. since 1985.
[219] Export crops have grown at 5.4% p.a.

Cotton/maize	Wide spread, covering **Mwanza, Shinyanga, Kagera, Mara**, Singida, Tabora, Kigoma, Morogoro, Coast, Mbeya, Tanga, Kilimanjaro and Arusha	Other crops grown are sweet potatoes, sorghum and groundnuts. Livestock rearing is also widespread.
Horticulture based	Lushoto district; Morogoro Rural; Morogoro region and Iringa rural	Other crops include vegetables, (cabbages, tomatoes, sweet pepper, cauliflower lettuce and indigenous vegetables) and fruits, (pears, apples, plums, passion fruits and avocado). Maize, coffee, Irish potatoes, tea and beans are also grown.
Wet – rice and irrigated	In river valleys and alluvial plains of Kilombero, Wami, Kilosa, Lower Kilimanjaro, Ulanga, Kyela, Usangu and Rufiji,	
Pastoralists and agro-pastoralist	Practiced in semi-arid areas i.e. Dodoma, Singida, parts of Mara and Arusha, Chunya districts, Mbeya and Igunga district in Tabora.	

Macro economic reforms continue to have significant impact on the agricultural sector with increased private investment in production and processing, input importation and distribution and agricultural marketing[220]. Government retains regulatory and coordination functions and is involved in creating conducive environment for the private sector to flourish.

Issue/Constraint: *Lack of coordination of programmes - Need to define more clearly the role of Donor Agencies and NGOs in the irrigation sub-sector*

Rainfed agriculture is affected by low and very variable rainfall[221]. It is dominated by smallholder farmers with average farm sizes of 0.9 to 3.0 ha. Many still use traditional hand hoe (~70%) with the reminder using ox plough (20%) and tractor (10%). Around 85% of cultivated land (5.1 million ha) is under food crops and women constitute the main part of agricultural labour force. The major staples include maize, sorghum, millet; rice, wheat, pulses (mainly beans), cassava, potatoes, bananas and plantains. Important export crops are coffee, cotton, cashew nut, tobacco, sisal, pyrethrum, tea, cloves, horticultural crops, oil seeds, spices and flowers. Within the Lake Victoria Basin, maize is the dominant crop (39%) with cassava (24%), sweet potatoes (14%) and rice (14%) being the other major crops. There has been some change over the years, but this mainly reflects the availability and distribution of rainfall. Irrigated crops of maize and rice have remained more or less constant. Mwanza and Mara achieve low yields, but all areas have considerable scope for improvement[222]. Data[223] on production of main food crops are given in Table 3.29 below. New export crops are emerging and the value of horticultural and floricultural exports expanded from US$ 9 million in 1999 to US$ 14 million in 2004. Support services and information dissemination are still a primary function of Government although it has been encouraging and advocating the

[220] Government has relinquished its involvement in production, processing and marketing sectors.
[221] 1/3 of the country receives <800 mm of rainfall and is thus arid/semi-arid; 1/3 receives 800-1000 mm.
[222] Farmers involved in the Participatory Irrigation Development Programme (PIDP), experienced increases in rice paddy yields from 0.5 to 4.0 tons per hectare.
[223] Annual statistical data (Basic Data Booklet) published by MAFSC

involvement and participation of the Private Sector[224], either independently or in collaboration with the Government.

Issue/Constraint: *The major constraint facing the agriculture sector is falling labour and land productivity due to application of poor technology, dependence on unreliable and irregular weather conditions. Both crops and livestock are adversely affected by periodical droughts.*

Urban agriculture (vegetable; food crops; milk, broiler meat and eggs) has developed to cope with the rising cost of living. It has flourished around towns and cities where there is a ready market with producers selling sell to private households, schools, hotels, hospitals, bars, cafeterias and restaurants.

Issue/Constraint: *Although Tanzania is not considered a food-deficit country and normally produces over 90% of food requirements of the population, the dependence of the agricultural sector on rain means that access to food is a major concern among many households in ARAL of the centre and north.*

Irrigation development involves around 1,428 irrigation schemes of which 1,328 are smallholder, 85 private and 15 government-managed schemes[225]. These are dominated by schemes of over 500 ha (58%), with only 3% occupied by small-scale schemes with an area of less than 50 ha each. Almost all schemes are gravity-fed (99%) from surface sources[226] with the remainder using pumps for water abstraction. Surface irrigation is practiced widely using furrows and basins with conveyance by both lined and unlined canals. Sprinkler irrigation is used by a few large-scale commercial farms[227] with drip rarely used except on pilot schemes run by Government or in small-scale water harvesting[228].

Issue/Constraint: *Water distribution methods should be determined, based on local conditions as well as social, technical and economic considerations and within the capacity and resources of the community to manage and maintain them. Attention needs to be given more to productivity and efficiency of water use.*

Traditional irrigation has been practiced in Tanzania since 1700 and more widely in a number of regions[229] since 1890. Many have deteriorated and become inadequate due to population increase, wear and tear, catchment degradation and a breakdown in traditional informal user organisations. Many are managed by Water User Associations (WUAs), either informal or formal, which are responsible for management, operation and maintenance (MOM) including water scheduling and planning. The main irrigated crops are paddy and maize, accounting for about 48% and 31% respectively of the irrigated areas in 2002. Other irrigated crops[230] account for 44% of irrigated areas with an average cropping intensity of 123%. More recently government has been implementing irrigation schemes in arid and semi arid lands (ASAL) based on traditional rainwater harvesting technologies together with storage dams[231]. These schemes have been improving upon the traditional management systems to handle the wider range of MOM tasks that is involved in these upgraded and modernised developments.

[224] In research; training; extension services; seed multiplication & marketing; procurement, distribution & marketing.
[225] NIMP, 2002
[226] Groundwater is utilized on only 0.2% of all irrigated areas.
[227] Private irrigation schemes produce cash crops such as tea, coffee, cashew and sugarcane.
[228] Government has been advocating the use of low cost irrigation technologies such as drip irrigation, through training of farmers and irrigation technical staff in the country and abroad.
[229] Arusha, Iringa, Tanga, Mwanza, Shinyanga, Kilimanjaro, Mbeya Morogoro and Ruvuma
[230] Beans, vegetables including onion, tomato and leaf vegetables, bananas and cotton.
[231] Smallholder Irrigation Development Project for Marginal Areas (SDPMA) and Participatory Irrigation Development Project (PIDP).

Issue/Constraint: *Inadequate farmer participation, focus on physical works, and insufficient clarity about the status of the systems and responsibility for management have been typical of the organizational culture of government-led small-scale irrigation development in the country.*

Irrigation potential has been estimated in the National Irrigation Master Plan (NIMP; 2002) at about 30 x 10^6 ha of which 7 x 10^6 ha have high or medium development potential. In Lake Victoria Basin 5.1 x10^6 ha exists in high/medium potential areas (Table 3.26). NIMP projected an increase in irrigated area from 264,000 ha (June 2006) to about 405,400 ha by 2017 (Table H.2) or 18% of the high potential area. Priority schemes to achieve this are given in Table H.3. It also emphasized the need to improve irrigation infrastructure, production practices, water management and adoption of new technologies[232].

Table H.2 Irrigation potential of Lake Victoria Basin

Region		Potential Areas (ha)			Total (ha)
		High	Medium	Low	
1	KAGERA	96,300	59,000	1,063,200	1,218,500
2	MARA	210,100	576,500	123,400	910,000
3	MWANZA	98,500	165,000	1,013,000	1,276,500
4	SHINYANGA	80,400	215,500	1,821,200	2,117,100
TOTAL		**485,300**	**1,016,000**	**4,020,800**	**5,522,100**

Issue/Constraint: *Experienced personnel not available for the production of suitably detailed design documents for irrigation schemes involve the use of private sector.*

Issue/Constraint: *The engagement of multi-disciplinary teams is not widely used and thus the appropriate skills needed when working with rural communities to define problems, identify solutions, develop and implement projects in a participatory manner are not available.*

[232] Government has launched an irrigation research programme to conduct experimental trials and field demonstrations to farmers throughout the country.

Table H.3 Projected Irrigation Development Areas in hectares

Projected Irrigation Development	Short Term	Medium Term	Long Term
	2003-2007	By 2012	By 2017
(a) Rehabilitation of Traditional Irrigation Schemes	179,800	216,100	274,600
(b) Development of Water Harvesting Schemes	41,600	57,200	68,200
(c) New Irrigation Schemes	43,800	51,600	62,600
Total	**265,200**	**324,900**	**405,400**

Issue/Constraint: *Insufficient funding and support for irrigation – Need to sensitise policy-makers and stakeholders on the importance and role of irrigation.*

Issue/Constraint: *Low investment in the sector by both government and private sector - Under the SWAP approaches; many areas with good potential for improvement of irrigation are not being addressed in a timely manner.*

Table H.4 Priority irrigation schemes in Lake Victoria Basin

Scheme		District	Area (ha)	Remarks/comments
1	Katunguru	Sengerema	910	Cereal production
2	Bugando	Mwanza	534	Cereal & horticultural crops
3	Bugorola	Ukerewe	200	Irrigation near confluence of 2 rivers, supplemented by pumping from Lake Victoria
4	Simiyu-Duma Valley	Magu	6000	Source will be Rivers Magogo and Moama, and Lake Victoria
5	Magogo Valley	Kwimba	3300	
6	Isanga Valley	Kwimba	2000	
7	Bugwema	Musoma	1600	
8	Geita plains	Musoma	2000	
9	Mara Valley	Musoma	6000	Large scale sugar scheme
10	Suguti Valley	Musoma	1500	
11	Manonga/Wembere	Kahama	70000	Diversion from Smith South
12	Biharamulo	Biharamulo	3000	

13	Nkono-Ikamba swamps	Bukoba	8000	
14	Kashasha Valley	Karagwe	3500	
15	Kabale Valley	Karagwe	2000	

Development costs for rehabilitation and upgrading of irrigation schemes has varied from US $ 2500/ha to US$ 4,500 /ha, depending on the extent of intervention with water harvesting developments such as PIDP varying from US$ 1,000 to 1,600 /ha.

Issue/Constraint: *Agriculture can contribute significantly to poverty reduction as it is the largest employer of labour, 80% of the poor are engaged in agricultural activities and studies have shown that, because of the value added and the consumption multiplier effect, agricultural growth actually accounts for 60% of the 5% growth rate in GDP.*

The major challenges to improved agricultural growth identified by MAFSC in the 2006 Agricultural Sector Review include (i) developing new sources of growth in response to markets, (ii) increasing farm productivity, (iii) improving agribusiness and processing to enhance rural employment, (iv) establishing producer incentives for export and food crops, (v) fostering the participation of the rural poor in agricultural growth and development, (vi) enhancing the sector investment climate, and (vii) improving public expenditures in the sector.

Issue/Constraint: *Government should encourage the development of irrigated agriculture, particularly by communities and the private sector, including individual farmers and ensure conducive environment for this process, including for example negotiating with banks to extend credits for irrigation development.*

Water Harvesting is a significant activity of the NGO sector. It involves in-situ techniques as well as structural storage and spate irrigation. In-situ techniques include contour farming; grass strips to break the flow of water down the slope; mixed cropping; crop rotations to prevent the build-up of pests, diseases and weeds and to improve soil structure and to maintain fertility; mulching to protect the soil surface, prevent erosion and conserve moisture in the soil; fanya juu to control water flow, prevent erosion and encourage the natural formation of terraces; terracing; check dams to slow down the flow of water and prevent further erosion.

Issue/Constraint: *Although in some areas of Tanzania, RWH is already widely practiced little technical support is extended to farmers by professionals and other bodies.*

Management of the water resources[233] lies with Ministry of Water (MW) and since the early 1990s, this has been based on river basins[234]. The establishment of Central and Basin Water Boards is aimed at harmonization and management of water resources at scheme level, Irrigators' Organizations (IOs), or Irrigators' Groups (IGs), have been formed and are expected to become the main actor in the irrigation sector, representing part of the private sector.

[233] Water resources development, water allocation, pollution control and environmental protection
[234] There are 9 designated River Basins: Ruvu/Wami; Pangani; Rufiji; Lake Nyasa; Lake Rukwa; Ruvuma/Lukuledi/Mbemkuru; Lake Natron/Manyara/Eyasi; Lake Victoria; Lake Tanganyika.

Issue/Constraint: *Lessons learnt from the River Basin Management Smallholder Irrigation Improvement project needs to be much more widely applied in order to improve overall water management.*

In Table H.6 below, more details on the identified constraints are presented. These derive from the Rapid Baseline Assessment reports and also experiences of donor and other agencies.

Table H.5 Food Crop Production, Areas and Yields in Lake Victoria Basin - Tanzania

Region	Crop	1999/00				2000/1				2001/2				2002/3			
		Area		Production	Yield	Area		Production	Yield	Area		Production	Yield	Area		Production	Yield
		10^3 ha		10^3 tons	kg/ha	10^3 ha		10^3 tons	kg/ha	10^3 ha		10^3 tons	kg/ha	10^3 ha		10^3 tons	kg/ha
KAGERA	Maize	60		72	1,200	45		104	2,300	102		124	1,200	104	28%	126	1,200
	Paddy	2		206	1,500	1		1	2,100	6		6	1,400	7	2%	14	1,954
	S/Potatoes	11		27	2,500	22		33	1,500					27	7%	70	2,615
	Bananas	81		243	3,000	78		234	3,000	167		840	5,018	141	39%	497	3,517
	Cassava	54		113	2,100	57		171	3,000	136		626	4,592	86	24%	113	1,311
	TOTAL	207				203				411				365			
MARA	Maize	48		58	1,200	48		95	1,773	59		98	1,700	37	24%	59	1,600
	Paddy	1		2	1,900	1		1	1,200	8		9	632	8	5%	14	1,773
	S/Potatoes	24		49	2,000	36		50	1,400	29		95	1,000	22	14%	29	1,331
	Bananas	13		28	2,100	23		63	2,700	6		17	2,775	3	2%	19	6,000
	Cassava	59		117	2,000	30		76	2,500	89		215	2,418	82	54%	282	1,000
	TOTAL	145				138				191				152			
MWANZA	Maize	110		132	1,000	85		153	1,200	173		261	900	136	28%	241	200
	Paddy	71		109	1,500	35		35	1,000	89		184	1,333	104	21%	243	2,335
	S/Potatoes	39		93	2,400	71		142	2,000	94		176	5,029	90	18%	151	5,966

	Bananas	3		5	1,800	5		7	1,300	3		2	862				
	Cassava	46		93	2,000	71		177	2,500	151		272	1,799	161	33%	290	1,799
	TOTAL	268				267				510				492			
SHINYANGA	Maize	169		169	800	134		201	1,500	342		347	1,000	314	61%	117	400
	Paddy	97		45	500	53		53	2,300	112		233	2,084	88	17%	128	1,462
	S/Potatoes	94		140	1,500	41		106	2,600	119		466	3,913	74	14%	164	2,225
	Bananas	1		1	1,700	0		0	1,100								
	Cassava	38		69	1,800	29		66	2,300	44		161	3,638	35	7%	96	1,216
	TOTAL	398				257				617				511			
TOTAL	Maize	387	38%	431		311	36%	552		676	39%	830		591	39%	543	
	Paddy	170	17%	362		90	10%	90		214	12%	432		207	14%	399	
	S/Potatoes	168	16%	309		169	20%	331		242	14%	737		212	14%	414	
	Bananas	97	10%	276		107	12%	304		176	10%	860		144	10%	516	
	Cassava	197	19%	392		186	22%	489		421	24%	1,274		365	24%	781	
		1,019		**1,770**		**864**		**1,766**		**1,729**		**4,132**		**1,520**		**2,653**	

Notes: Blanks in table means that data are currently not available

Table H.6 Main Identified Constraints – Tanzania

	Constraint/Issue	Remarks
A	**Water Resources Management**	
	Increased demand and pollution of water resources	Lessons learnt from the River Basin Management Smallholder Irrigation Improvement project needs to be much more widely applied in order to improve overall water management.
	Deforestation of catchments, resulting in soil erosion and sedimentation in canals	Need to identify and promote options for enhancing quality of natural resources by addressing environmental problems of deforestation, soil erosion and sedimentation, salinity, etc.
B.	**Agricultural production**	
	Technology development and transfer	The Government should work with the private sector towards the establishment of farm service centres to facilitate farmers' access to appropriate technology and equipment to increase the work efficiency and reduce the need for manual labour.
	Poor crop and animal husbandry practices	Continued use of hand tools by the majority of producers
	Dependence on rain-fed agriculture	
	Decline in the use of improved seed, fertilizers and agrochemicals.	High cost and unreliable supply of modern inputs
	dependence on erratic rains for agricultural development	Government should encourage the development of irrigated agriculture, particularly by communities and the private sector, including individual farmers and ensure a conducive environment for this process, including for example negotiating with banks to extend credits for irrigation development.
	HIV/AIDS and malaria threats that are eroding the country's manpower	It has been observed that HIV/AIDS and malaria threats that are eroding the country's manpower, including the farming community. Existing disease control programmes, particularly for HIV/AIDS and malaria should therefore be strengthened and their coverage expanded to include services to the farming communities in rural areas.
C.	**Extension/Support Services**	
	Low staff motivation	Due to low remuneration, insufficient technical support and training and a lack of supervision.
	Lack of training on new crops and technologies	
	Markets	
	Volatile and unpredictable international markets.	Dissemination of market information more widely, in a user friendly manner and aimed at assisting farmers in the choice of appropriate crops and planting dates.
	Few functional marketing organizations, with the collapse of the unions	
	Lack of value-adding at farm or village-level	
	Limited of information about prices and quality requirements	Current arrangements for extension support to not meet the demands of farmers.
	Finance	
	Low investment in the sector by both government and private sector.	Under the SWAP approaches, many areas with good potential for improvement of irrigation are not being addressed in a timely manner.
	Economic and financial issues, including investment in irrigation development	The key issues include: poor cost recovery for O&M; inadequate public funds and cost recovery from users; low financial capability for proper irrigation O&M; inadequate credit schemes as sources of funds for farmers; absence of incentives for efficient water use.
	Lack of access to credit facilities	Includes limited access to financial services
D.	**Livestock Development**	
	Gender issues, consideration and mainstreaming;	Irrigated agriculture has a number of gender dimensions, which should be taken into consideration right from design. When the irrigation scheme is for production of food crops, as is the case in most small scale community projects, the project may lead to increased work load for women because in many communities, women are usually the food producers. This was clearly demonstrated by the Women in Agriculture (WIA) project (1988), which assessed impact of irrigated rice production on, inter alia, the status of women's work load.
E.	**Irrigation development**	
	Planning and designs	
	Inadequate data for proper planning/management	The preparation of good project documents, an activity which lends itself to out-sourcing, including from the private sector;
	Low performance of irrigation due to inappropriate design, aging infrastructure and	
	Inadequate irrigation planning and designs.	The engagement of multi-disciplinary teams is not widely used and thus the appropriate skills needed when working with rural communities to define problems, identify solutions, develop and implement projects in a participatory manner are not available.
	Manuals available not geared to staff needs/capacities and are not standardised.	Different manuals exist on principles of irrigation planning and design and where appropriate, sections need to be translated into Kiswahili to enhance farmers' participation in the design process.
	Lack of appropriate modern technical equipment	The use of modern survey equipment and instruments will tremendously increase the efficiency of survey teams.
	Preparation of project documents	Experienced personnel not available for the production of suitably detailed design documents for irrigation schemes involve the use of private sector.
	Implementation	
	Poor quality of irrigation works and slow rate of development	Lack of interest by competent companies in scale of small irrigation works in rural areas.
	Water management/ distribution services;	
	Main water distribution methods	A water distribution method should be determined, based on local conditions as well as social, technical and economic considerations. The water distribution method is normally a function of the design of the conveyance system.
	Poor conveyance efficiency	Identify and evaluate options to reduce water losses in irrigation systems

Table H.6 Main Identified Constraints – Tanzania (Continued)

	Constraint/Issue	Remarks
	Operation and Maintenance	
	Malfunctioning of many irrigation schemes	Lack of proper operation and maintenance is an overriding cause & results in the poor performance & operation of irrigation
	Poor cooperation	Poor man-management, conflicts between farmers, lack of incentive for operational personnel to do a good job;
	Lack of technical skills in planning, implementing and monitoring the system;	
	Technical deficiencies in system due to poor maintenance or faulty design.	Schemes with aging irrigation infrastructure should be rehabilitated simultaneously with establishment of effective WUAs,
	Low participation of farmers	
	Inadequate assessment of farmers resources/ability	Low financial capability for proper irrigation O&M Absence of incentives for efficient water use
	Government cannot fund O&M Adequately	Heavy reliance on government support with little involvement and contribution from the beneficiaries
	Water Users Associations	
	Principles of formation and management of Irrigators' Organizations;	Inadequate farmer participation, focus on physical works, and insufficient clarity about the status of the systems and responsibility for management have been typical of the organizational culture of government-led small-scale irrigation development in the country.
	Funding for O&M	Irrigators' Organizations not sufficiently organised to collect funds from farmers to meet the needs of the system for routine O&M.
	Weak Irrigation Organisations	While the majority of Irrigators Associations are weak, it should be noted that in some schemes they are missing altogether
	Farmers' organization required to manage	There is need to promote participatory planning, monitoring and evaluation
	Inadequate Technical skills	As such it is very important that their capacities are enhanced through adequate training and extension support as well as availing them with inputs and credit support. Their organizations should also be strengthened in terms of management
	Incentives for farmer improvement	With financial data available it is possible to show the profitability of the irrigation systems, and thus convince farmers to sustain and even improve the productivity of irrigated agriculture through the mobilization of their own local resources.
	Irrigation scheme leadership in the villages;	Inadequate leadership create conflicts in water use particularly when they do not work closely with the Village Government Leaderships in the allocation of water that is also be required for other uses, including domestic and livestock requirements..
	Conflict resolution and management in the schemes;	All members of the Irrigators' Organization should be made aware of relevant existing and new legislations with regard to water management and use. They should also participate in the formulation of relevant bye-laws and other mechanisms of conflict-resolution.
	Water Users' Associations (WUAs) are not performing very well	Due to inadequate training in organizational management and scheme operation and management, a result of inadequate budgetary allocation for facilitation/extension services in irrigation sub sector. There is a need for Need of effective support system to WUAs' activities.
	Constraints to Public Private Managed Irrigation	The public private irrigation (large scale) category of irrigation schemes has also been encountering a number of constraints. To a large extent, these constraints are similar to those that the community irrigation schemes are confronted with, although there are some more specific ones. Generally, the following are the major constraints of this category:
F.	**Water harvesting**	
	Inadequate support (Little technical support is extended to farmers)	Although in some areas of Tanzania, RWH is already widely practiced, little technical support is extended to farmers by professionals and other bodies.
	Upscaling of Water harvesting techniques	Although in some areas of Tanzania, RWH is already widely practiced, it needs support from formal organizations (government and NGO) for its further technical development and geographic spread. The support should include farm visits and on-farm demonstrations together with dissemination of a range of knowledge-sharing information products
	Improved use of rainwater	The shortage of water in semi-arid and arid areas results from insufficient knowledge to manage the rainfall/runoff. The most critical management challenge is how to deal with the poor distribution of rainfall that gives either flooding or water shortages.
	Inadequate information on techniques available	According to the findings of the SUA/DfID RWH research programme, access to multiple sources of information on RWH was found to be one of the key factors in its adoption by farmers, and in the capacity of field-level service providers and policy-makers and planners to be pro-active in supporting RWH development.

Table H.6 Main Identified Constraints – Tanzania (Continued)

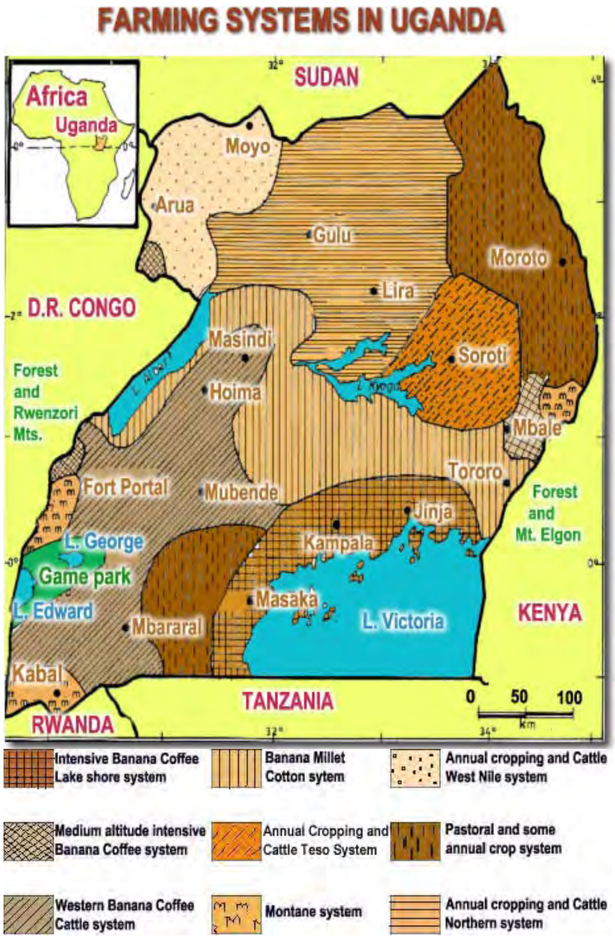
	Constraint/Issue	Remarks
G.	**Institutional Aspects**	
	Research-development linkage	
	Weak research-development linkage (Weak links between research and farmers or communities)	There is poor adoption of effective techniques and technologies for RWH due to weak links between research and farmers or communities. Comprehensive communication, covering all stakeholders who have roles in the uptake and scaling-up processes is needed.
	Monitoring of results	In the implementation of research programmes, impact monitoring and evaluation system at household level. Farm visits and on-farm demonstrations are effective tools for improving farmer and extension agent awareness on RWH.
	Poor adoption of effective techniques and technologies for RWH	There is due to weak links between research and farmers or communities. Comprehensive communication, covering all stakeholders who have roles in the uptake and scaling-up processes is needed.
	Application/adoption of research findings	Research findings on agronomic packages, crop/water consumption relationships, on-farm water management principles and appropriate crop varieties and variety mix are not adopted by farmers at the rate that would enhance the productivity of irrigated agriculture. This has been exacerbated by the lack of a feedback system on the lessons learnt through actual experience in implementation of irrigation projects
	Research and academic institutions have inadequately kept pace with development of cost effective irrigation technologies.	This is particularly for use by smallholder farmers. Private sector actors would greatly benefit from requisite training. There is need for close collaboration and coordination but no mechanism no comprehensive system has yet been established for this purpose.
	Infrastructure	
	Poor rural infrastructure	This limits farmers' access to markets for inputs and products.
	Non availability of electricity in rural areas.	Restricts use of cheaper alternatives for pump schemes as rural electrification does not reach the rural areas associated with many irrigation schemes
	Institutional	
	Lack of coordination of programmes	Need to define more clearly the role of Donor Agencies and NGOs in the irrigation sub-sector
	Insufficient support for irrigation	Sensitise policy-makers and stakeholders on the importance of irrigation
	Capacity building	
	Inadequate trained personnel	Training of personnel in: (i) Principles of formation and management of Irrigators' Organizations; (ii) Principles of irrigation
	water management capabilities	
	Broader participation	
	Information management and dissemination	
	Information management facilitation services to the IOs;	There has been limited involvement and participation of Non Governmental Organizations (NGOs), Community based Organizations (CBOs) and the Private Sector due to a variety of reasons, including capacity limitations on their part. There has also been a lack of human resources and active participation of Local Government Authorities (LGA) in irrigation development.
		The Government has established a database for information on irrigation development activities. There is need for further financial support to ensure that the database is used effectively for information management and dissemination. This also applies to the availability and use of guidelines and manuals in planning, design and construction supervision

ANNEX I – UGANDA COUNTRY OVERVIEW

Uganda

Most of Uganda lies within the Nile Basin and is located on the equator, covering 241,000 km^2, 18% of which is occupied by water or swamps (Table I.1). More than two-thirds of the country is 1,000 to 2,500 meters high. Precipitation[235] is fairly reliable and varies from 750 mm/an. in the Karamaja pastoral areas in the Northeast to 1,500 mm/an. in the high-rainfall areas on the shores of Lake Victoria, around the highlands of Mt. Elgon in the East, the Ruwenzori Mountains in the Southwest, Masindi in the West, and Gulu in the North.

After the positive growth in the 1960s, the agriculture sector experienced negative growth rates (average -2% per annum) in the 1970s due to civil strife, economic mismanagement, disintegration of public infrastructure and services, lack of private-sector investment, scarcity of foreign exchange for agricultural inputs and the collapse of the emerging commercial agricultural sector. Government's Economic Recovery Programme introduced in 1987 and the Structural Adjustment Policies of the early 1990s, have progressively achieved a stable macro economy, and have promoted growth through establishing a conducive and enabling environment for private sector investment. The focus has been on rehabilitation of infrastructure for traditional exports (coffee, cotton, tea and tobacco); development of non-traditional exports; removal of physical, technical and institutional constraints for agricultural development; agricultural pricing, trade and marketing liberalisation and strengthening agricultural research and extension.



The economy is dominated by agriculture that accounts for 43% of GDP, 85% of export earnings, 80% of employment and provides most of raw materials to the mainly agro-based industrial sector[236]. Only 5 x 10^6 ha (30% of arable land) is currently under cultivation and although it would appear that there is considerable scope for expansion, some parts of the country have very high population densities[237]. Agricultural output derives from about 3 million smallholder farmers (average size of landholding is 2.2 ha) who constitute three-fourths of the total 22 million people (85% of the population) who

[235] Near the equator and around the Lake Victoria Crescent there are two distinct rainy seasons.
[236] Comprising coffee hulling, cotton ginning, tea processing, sugar production, textile mills, soap industries, edible oil industries, cigarette manufacturing, grain milling, meat processing, dairy and leather products manufacturing
[237] Population densities are highest in districts around Lake Victoria, and in highlands of Southwest, the country's most fertile areas and consequently are those areas most at risk from soil erosion. Northern region has less than half the average rural population density with only 49 persons/ km^2.

live in rural areas and depend mainly on agriculture for their livelihood. The hand-hoe is the predominant technology for cultivation of the mainly food crop production that predominates, contributing 71% of agricultural GDP, with livestock products (17%), export crops (5%), fisheries (4%) and forestry (3%) making up the balance. Only a third of the food crop produced is marketed compared with 2/3 of livestock produced. About 42% of agricultural GDP consists of subsistence crops for home consumption and is non-monetized. Bananas cover the largest cropped area (28%), followed by cereals (25%), root crops (17%), pulses (14%) and oil seeds (8%). Export crops constitute only 8% of total cropped area. Farming systems in Uganda are divided into seven broad agro ecological zones (Table I.2) based on soils, topography, rainfall and major crops grown. The main feature is mixed enterprises with food crops as the dominant activity supplemented by a few export crops such as coffee, cotton, tea and tobacco and livestock. In the pastoral farming systems which exist in the northeast and a part of the west, livestock production constitutes the dominant activity supplemented by production of a few food crops.

Table I.1 Summary of Uganda's Agricultural Resource Base

GEOGRAPHICAL AREA (Sq. Km)		
Land Area	-	197,097
Water and Swamps	-	43,942
Total Area	-	241,039
POPULATION AND HOUSEHOLDS (2000)		
Total Population	-	22,210,000
Rural – Male	-	9,293,000
- Female	-	9,353,000
- Total	-	18,646,000
No. of Rural Households	-	3,056,418
Average size of Rural Family		7.3
Density	-	92
LAND UTILIZATION (Ha)		
Cultivable Land	-	16.7m
Forest Land	-	1.53m
Area Cultivated	-	5.20m
Av. Size of Land Holding		2.2
AGRICULTURE GDP – 1999 (Current prices)		
Monetary (Shs in Billion)	-	2,046

Non-monetary (Shs in Billion)	-	1,443
Total Agric. GDP (Shs in Billion)		3,489
Share of Agric. In Total GDP		44%
Share monetary Agric. GDP in Total Agric. GDP		59%
CROPPING PATTERN (1999)	Area (000 Ha	%
Banana	1510	28.15
Total Cereals	1341	25.00
Root Crops	895	16.69
Pulses	750	13.98
Oil Seeds	428	7.98
Export Crops	440	8.20
Total	5363	100.00
AGRICULTURAL EXPORTS (1998)		Amount (US$ x 10^6)
Coffee		295.67
Other Traditional Exports		57.97
Non-traditional Exports		182.88
Total Exports		536.51
Share of Agricultural Exports		85%

Source: Agricultural Policy Secretariat.

Table I.2 Summary of Uganda's Agricultural Systems and Major Crops

Farming System	Districts	Major Crops Grown	Remarks
1. Teso	Soroti, Kumi	Millet, maize, sorghum, groundnuts, sunflower, cotton are major crops. Mixed agriculture (crops and livestock) is practiced, groundnut, simsim, sweet potatoes, cassava also grown.	The area receives bimodal rainfall on sandy-loams of medium to low fertility; Dry season is longer (Dec-Mar).
2. Banana/ Coffee	Bundibugyo, parts of Hoima, Kabarole, Mubende, Luwero, Mukono, Masaka, Iganga, Jinja, Mpigi and Kampala	Robusta coffee and banana (main cash crops), maize, beans, sweet potatoes, cassava, horticultural crops, tea, groundnut.	Rainfall is evenly distributed (1000 - 1500 mm/year), bimodal, on soils of medium to high productivity.
3. Banana/ Finger millet/ Cotton	Parts of Masindi, Luwero, Kamuli, Pallisa and Tororo	Cotton, Robusta coffee, beans, maize	Rainfall is less stable than for the banana-coffee system, greater reliance on annual food crops (millet, sorghum and maize).
4. Northern	Gulu, Lira, Kitgum, Apac	Cotton, tobacco, simsim, finger millet, sorghum, cassava, sunflower groundnuts are major crops.	Rainfall is less pronounced bimodal (~1200 mm/an).
5. West Nile	Moyo, Arua, Nebbi	Mixed cropping is common with a wide variety of crops; tobacco and cotton are major cash crops. Arabica coffee, simism, millet, sorghum, cassava, groundnut also grown.	Rainfall pattern resembles that of northern system, with more rain at higher altitudes.
6. Montane	Kabale, Rukungiri, Kisoro, Bushenyi, Kasese, parts of Kabarole, Mbarara, Mbale and Kapchorwa	Arabica coffee, banana, cotton, maize, beans, wheat and barley, millet, rice, Irish potatoes and sweet potatoes	Found at higher elevations (1500 - 1750 mamsl); high and effective rainfall.
7. Pastoral	Rakai, parts of Mbarara and Masaka, Kotido and Moroto	millet, cassava, sorghum, beans, maize	Annual rainfall is low (under 1 000 mm/an); characterized by short grassland where pastoralism prevails with nomadic extensive grazing.

Grazing management systems for cattle, which are superimposed in varying degrees and combinations on the above crop farming systems, have traditionally included communal grazing, pastoral herding, tethering, enclosed ranching, fenced dairy farms and zero grazing (recent). Several variants (particularly for fenced dairy systems) of these systems exist and their classification is mainly based on input usage, proximity to market outlets and potential for commercialization.

Issue/Constraint: *Lack of water sources and pastures necessitates migration of cattle herds in search of water and pasture in the dry season. This is particularly striking in Karamoja, where transhumance is associated with cattle raiding in areas to the south.*

Forest reserves cover 1.5 million ha. (~ 7% of the country) and comprise 732,000 ha high tropical forests, 775,000 ha. savannah forests and 25,000 ha plantation forests. Forestry contributes about 2% of GDP and provides over 95% of the county's timber requirements with about 400,000 ha. available for industrial use.

Fisheries account for about 3% of GDP using the country's plentiful fresh water resources comprising natural lakes[238], rivers, dams, tanks and swamps that cover about 17% of the total area. The sub-sector is dominated by private fishermen, traders and exporters. Sustainable harvest is estimated at about 300,000 t/an and reached about US $50 million in 1995/96 making fish exports the second largest foreign exchange earner to coffee. There is scope for expanding fish production by developing aquaculture and provision for high yielding and quick maturing fish.

Issue/Constraint: *Poor market facilities - women appear to be most affected by inadequate market facilities, such as sanitation or shelter. Although both men and women are involved in marketing, women may have limited access to the profit.*

Agricultural extension has served few farmers and its messages and approaches have not been effective. Financing and delivery mechanisms have not been efficient and sustainable and for a long time extension has been inherently donor driven and non-participatory, being characterised by too much bureaucracy and low responsiveness to the farmers' needs. This has made it susceptible to diminished budgetary support with a lack of financial and performance accountability and client ownership further aggravating the situation. The research-extension-farmer linkages and the delivery systems and mechanism have also been inadequate and this is compounded by lack of access to sustainable knowledge, information and communication; lack of access to productivity enhancing technologies; lack of extension policy; and poor linkages, empowerment and co-ordination mechanism.

These issues are being addressed under the National Agricultural Advisory Service (NAADS) that puts greater emphasis on extension delivery and advocates an agricultural advisory service (AADS) that is owned by stakeholders, effective, efficient, sustainable to deliver and market targeted. Rather than engaging in "delivery" of messages or inputs, the agricultural advisors (AS) will engage their clients in critical thinking and discussions about their agricultural endeavours, and about the management of their farms as a business enterprise rather than engaging in delivery of messages and inputs for its own sake. The underlying principle being adopted is to have advisory services where the farmers are empowered as partners and have a role to play. The work programmes and activities of these advisors will be determined by farmers themselves. The advisors will therefore effectively become *de facto* employees to farmers, rendering advisory services to help farmers make better decisions about their farms. It is with this vision in mind that NAADS will be instituted under the PMA in place of the current Agricultural Extension system.

Issue/Constraint: *The research system is not closely linked to the farmer; extension services are not adequate and reach few farmers (Extension service reach of 5-10% of farmers; Reach to LC I areas – 16%, 33%, 9% and 45% in Central, Eastern, Northern and Western regions); rates of technology adoption is below 30%..*

[238] The largest and most resource-rich are Lake Victoria, Lake Kyoga, Lake Albert, Lake Edward and Lake George.

The implementation of policy and institutional reforms resulted in the liberalisation of marketing of agricultural produce, abolishment of export taxes and removal of other market distortions. Regulatory and promotional agencies were also established for key export crops, quality control and market information dissemination. Despite all this, the welfare of the majority of subsistence farmers has not improved substantially, although the proportion that lives under the absolute poverty line has declined from 56% in 1992/93 to 44% in 1997/98[239]. Household incomes are still low and food security is not guaranteed. A survey[240] in 14 districts indicated that at any one time, about 40% of the population are food insecure. Only one third of total food production is marketed, up to 60% of household expenditure is spent on food[241], and 56% of total agricultural GDP is subsistence production for household consumption.

Issue/Constraint: *Barriers to access and utilisation include cost; theft; unavailability in nearby markets; poor quality; and lack of advice. Uganda National Household Survey indicate that in 1995-6, only 1% of poor farmers use improved seeds. About one fifth of better-off farmers use improved seeds in the central, eastern and western regions.*

Poor farmers stated that poverty was due to low production – crops, livestock and fish catch. They were (i) unable to provide sufficient food for the household throughout the year; (ii) unable to supply basic household essentials, or to afford education and medical costs; and (iii) sometimes forced to sell assets, such as land, livestock and produce meant for household consumption, in order to meet basic household needs.

Table I.3 Summary Ranking of Cause of Poverty (UPPAP, 1999)

FACTOR	% OF RURAL SITES
Lack of access to markets	63
Poor health	58
Lack of education and skills	58
Excessive alcohol consumption	54
Ignorance/ lack of information	54
Lack of access to financial services and capital	42
Large families	42
Insurgency (rebels and rustlers)	38
Idleness and laziness	33
Lack of co-operation	17

Irrigation is a relatively new as rainfall has been more or less sufficient in the past. Most parts of the country experience at least one long rainy season and this has been sufficient for farmers to produce at least one crop a year. In the past, irrigation was only practiced during the dry season at small-scale informal level with most of this located on the fringes of swamps. Nowadays rainfall has become less reliable with supplementary irrigation needed in rain season at times and much of this has been developed by smallholders without planning

[239] Household expenditure survey date by the Uganda Bureau of statistics
[240] By the Economic Policy Research Centre (EPRC) in 1998
[241] Poverty Status Report, 1999.

and with little or no technical assistance. The technology used is basic and approaches are sometimes inappropriate. Formal irrigation developments commenced in the 1960s and currently around 56,000 ha are currently irrigated (Table I.4). Most smallholder schemes grow rice and vegetables, with the larger commercial estates cultivating rice and sugarcane. Most irrigation developments use surface methods although the more recent developments involving green house irrigated flower farms that started in 1990s utilised drip and micro sprinkler.

Issue/Constraint: *The progress with formal irrigation has been very slow and with limited success. One reason is the top-down approach adopted in most schemes. There is limited experience of water users associations in the country and the requirements for successful formation and the involvement of the beneficiaries from the start of any project interventions.*

Potential irrigation areas for expansion are found in the Lake Kyoga catchment (Teso systems and Banana/Millet/Cotton System), the Western Region (Montane System and Banana/Coffee System), the Albert Nile Valley (West Nile System), and in the Jinja, Iganga districts on Lake Victoria in the southeast of the country (Banana/Coffee System).

Issue/Constraint: *Some work has started on the water for production component (WfP) for Uganda, but this has still a long way to go. An irrigation policy has been prepared in draft and this will be elaborated upon in 2008. There is a strong need to clearly establish the needs for irrigation and drainage and the process by which it can be realised. This needs to go hand in hand with the training of technical staff to support any proposed interventions.*

Table I.4 Summary of Existing Irrigation in Uganda

Irrigation project	District , AEZ	Source of Water	Main Crops	Command area (ha)	Present irrigated area (ha)	AEZ
Formal Schemes						
Mubuku	Kasese ,	ebwe /Mubuku	Onions Vegetables Alfalfa	600	430	3
Kimbimba(Tilda)	Iganga	Kimbimba reservoir	Rice	600	600	1
Doho	Tororo(Butaleja)	Manafwa	Rice	1000	1000	2
Kiige	Kamuli	Nabigaga Lake	Citrus	150	10	2
Ongom	Lira	Owomwri/ Ongom River	Citrus	40	10	5
Labori	Soroti	Kyoga Lake	Vegetables	40	0	4
Atera	Apac	Kyoga Lake	Rice, Vegetables	20	0	5
Agoro	Kitgum	Agoro River	Rice, Vegetables	120	120	5
Olweny	Lira	Olweny	Rice	50	50	5
Large- Scale						

	Tororo	Mpologoma Lumbika Manafwa	Rice	24,500	24,500	2
	Iganga	Mpologoma Kitumbezi Lumbuye	Rice	2,400	2,400	1
	Palisa	Mpologoma	Rice	10,800	10,800	2
	Others		Rice	15,650	15,650	
Commercial						
Nyamugasani	Kasese	Nyamugasani	Vegetables, Cotton, Sugarcane, Maize, Rice	360	10	3
Lugazi	Jinja	Victoria Lake	Sugarcane	2000	50	1
Kakira	Mukono	Sezibwe	Sugarcane	600	50	1
Total				**58,930**	**55,650**	

Water Harvesting involves mainly storage systems including small pots, water jars corrugated galvanized tanks, plastic tank and Ferro cement/masonry tanks for domestic system (Table I.5). Considerable efforts have been made to improve livestock watering especially on migratory routes from north east to south west using subsurface masonry tanks, ponds and valley tanks/dams. The country also has a long record of using in-situ measures in the rainfed lands for improving moisture retention for agriculture production and environmental conservation. In spite of this, adoption of technologies is not widespread and there has been insufficient adoption of all potential RWH techniques.

Issue/Constraint: *The full range of technologies available for domestic drinking and livestock water in rural areas and for backyard crop cultivation from storage need to be available and extension staff trained and provided with appropriate information. Most affected from the effects of scarce water are women and children who are primarily given the role of fetching water.*

The quality of the extension services will be one reason for the poor uptake and the concentration more on individual rather than community water harvesting techniques. These extension services are being addressed under the revised agricultural policy, but they will be aimed at improving rainfed agriculture rather than supporting water harvesting and irrigation.

Issue/Constraint: *Extension staff will need to be trained and provided with transport and fuel to support any irrigation and water harvesting interventions. Incentives and guidance will be needed to motivate staff who will need to be provided with training manuals and guidance for the farmers. It is hoped that once established, farmers will see the benefits of advice on water harvesting and this could be supported through service providers from the private sector. Extension services being replaced by NAADS (National Agricultural Advisory Services) which has long term goal of privatising extension services. The transmission is not smooth and leaves a lot of gaps. Most farmers are still basically subsistence farmers and can not afford private services.*

Table I.5 Water harvesting technologies/ practices found in Uganda

Water harvesting Technology/ practice	Use	Example Location of practice	Evaluation factors					
			Benefit	Maintenance/ Management	Cost	Spare parts availability	Technical support	Water use efficiency
Valley dam	Watering animals, domestic	Mbarara, Luwero	Water	Fairly difficult	High $100,000 -200,000	Local materials	District/ DWD/ NARO/ MAAIF	Average (high ET losses)
		karamoja	Time	Poor				
		Pastoral zone	Health					
Valley tank	Watering animals, domestic	Mbarara, Luwero	Water	Fairly easy,	Average high $20,000 -100,000	Local materials	District/ DWD/ NARO/ MAAIF	Average (high ET losses)
		karamoja	Time	Fair ,,good				
		Pastoral zone	Health					
Pots, jars	Domestic	Masaka, Mbarara	Water	Easy,	Cheap $85 - 160	Local materials/ Town	Group/ NGO/ DWD/ Individual	High (low evaporation losses)
			Time	Good				
			Health					
Corrugated galvanized tanks	Domestic, backyard irrigation	Bushenyi, Masaka, Mbarara	Water	Easy ,	Average up to $3,500	Kampala/ Town	District/ DWD/ NARO/ MAAIF/ URWA	High (low evaporation losses)
Plastic Tanks			Time	good				
			Health					
Ferro cement tanks	Domestic, backyard irrigation	Mbarara, Masaka	Water	Easy, Good	Fair $300-1,000	Local materials/ Town	Group Mason/ NGO/ DWD/ Individual/ URWA	High (low evaporation losses)
			Time					
			Health					
Brick masonry tanks	Domestic, backyard irrigation	Mbarara, Masaka	Water	Good	Fair $300-1,200	Local materials/ Town	Group Mason/ NGO/ DWD/ Individual/ URWA	High (low evaporation losses)
			Time					
			Health					

Subsurface masonry tanks	Domestic, backyard irrigation	Mbarara, Masaka	Water	Fair	Fair $300-1,700	Local materials/ Town	Group Mason/ NGO/ DWD/ Individual/ URWA	High(low evaporation losses)
			Time					
			Health					
In-situ, internal & external storage for agriculture	Agriculture, environment	Luwero, Mbarara, Bushenyi, Masaka	Yield increase	Good	Cheap - Farm labour	Local	District/ NARO/ MAAIF	High
			Soil conservation					

Growth in the agricultural sector during the 1970s and 1980s was hampered by a series of policy and structural constraints related to such factors as: (i) government and Parastatal monopolistic control of food and export crop marketing and pricing that inhibited incentives to improve the quality and quantity of output; (ii) inadequate infrastructural facilities; (iii) shortages of foreign exchange, for importation of critical agricultural inputs and high and unpredictable inflation; and (iv) insecurity. In addition, there were institutional constraints, which included; (i) ineffective and inefficient government research and extension services; and (ii) segmented, inefficient and discriminatory markets for capital, labour, land and agricultural inputs. Most of these have been removed during the implementation of the Agricultural Policy Agenda of the Economic Recovery Programme during the past decade, but fundamental constraints affecting growth in the sector still exist. These derive from a number of issues, many of which are deep-rooted constraints that could not yet be addressed sufficiently. These include marketing infrastructure constraints, technology generation and dissemination, financial constraints, land tenure and policy, farmers' organisations, human resource constraints, information constraints, on-farm and off-farm storage, environmental degradation and the effects of HIV infection.

Issue/Constraint: *Many communities blame the lack of productivity on the lack of information, knowledge and skills concerning better methods of food and income-generation (crop production, animal husbandry, fishing methods and alternatives), soil conservation, pest and disease control, marketing opportunities, prices, processing and pertinent government policies and regulations.*

Education for Agriculture: Poor farmers identified low education levels, ignorance, lack of information and lack of skills – particularly in primary production and financial management - as factors influencing their inability to access and benefit from livelihood opportunities, and subsequently as causing poverty[242]. As such the human capital of all stakeholders – pupils, parents, farmers, local government, implementers, and researchers - must be developed in order to transform agriculture and consequently eradicate poverty. This can be achieved through informal education, such as efficient extension and more formal or targeted interventions in the education sector.

Issue/Constraint: *At present there are no effective grassroots/village-based, commercially oriented institutions capable of mobilising the production capacity of small producers for the production of income-generating commodities. The co-operative movement, which was effective in mobilising farmers in this fashion, has not been able to perform this function in the past decade.*

Agricultural marketing in Uganda is currently constrained by a number of factors related to the road network, transportation, market facilities, communication and information system, and facilitating services including research and extension. Road infrastructure in Uganda, while improving is still under-developed in terms of its network and state. More that 90% of

[242] *Uganda Participatory Poverty Assessment* 1999

Uganda's road network consists of earth and gravel roads and about 25% of the rural feeder roads are impassable during the rainy seasons. In addition there is a myriad of community roads that are in poor state but yet very important to linking local communities with the market. Given that poor road infrastructure is the most significant constraint to subsistence farmers' accessibility to the market, the construction and maintenance of feeder roads as well as community roads will become top priority for LGs during the PMA implementation. Agricultural exports are constrained by poor trunk roads, an inefficient railways and water system, lack of landing sites with adequate facilities to handle quality exports and an inadequate airline system.

For the majority of agricultural produce, the main means of transport is through carrying of load on the head, which is estimated to amount to about 70% of total marketed produce in Uganda and is undertaken mainly by women. The bicycle transports about 20% of marketed produce while motorised transport carries about 8%. Donkeys and ox-carts are used for transporting the remaining 2% of marketed produce. To improve marketing access the subsistence farmer has to shift in the short to medium term to Intermediate Means of Transport (IMTs) including bicycles, donkeys, ox-carts and motorcycles. Although means of transport was ranked as the second most constraining factor to market access in the NRI/APSEC study, little attention has been paid to it by policy makers in Uganda over the past years.

In rural Uganda markets generally lack essential facilities like all-weather structures, secure storage, safe water and healthy sanitation structures. These amenities have significant impact on market access.

Issue/Constraint: *The restricted access to markets and market dues constrains the produce that farmers can grow. Ready markets are not available for sale of produce and purchase of inputs; long distances to produce markets, impassable roads and lack of affordable transport,]. High market dues for produce sales in general, relative to low incomes are said to eat into market profits.*

Post harvest losses in Uganda are unacceptably high and are estimated at 5 – 15% for non-perishable crops (grains), 20 – 35% for semi-perishables (root crops) and 40% for perishables. Apart from inefficient primary processing facilities, the other key factors responsible for post-harvest losses are lack of appropriate storage facilities and inadequate cold storage facilities for perishables such as fish, meat, fruits and vegetables.

Issue/Constraint: *The loss of 35-40% of crops to disease and pests severely limits productivity of both food and cash crops – cassava, coffee, banana, tobacco, groundnuts and cowpeas. Poor farmers are unable to cope with diseases and pests because of a lack of money, limited availability of drugs and pesticides, lack of or misguided advice, conflict with Government regulations and officers. Poor post harvest handling: poor /inadequate storage and processing facilities, value addition*

The communication system in Uganda composed of radios, print media, telephones, faxes, etc are beginning to pick up but their coverage of up-country towns and rural areas is still grossly inadequate. However, there is general inadequacy, unreliability and lack of timely agricultural information reaching farmers, traders and consumers. This problem covers the whole range of market, commercial, technical and institutional information. This current state of affairs of inadequate, unreliable and untimely information flow constrains market access and at the national level it also contributes to the situation whereby food surplus in some parts of the country co-exist with transitory and even chronic deficits in other parts. At policy level, it renders meaningful planning impossible.

Issue/Constraint: *The availability of statistics regarding food crops and export crops is unsatisfactory with many agencies involved in the collection and dissemination of agricultural data. There is therefore an urgent need for the establishment of information services that is acceptable to producers and market operators.*

Facilitating functions for market access including promotion and development of community organisations, rural financial systems, and research and extension services are covered extensively elsewhere in this document and will not be dealt with in this section except to note that they are absolutely crucial in improving marketing access.

In Table I.6 below, more details on the identified constraints are presented. These derive from the Rapid Baseline Assessment reports and also experiences of donor and other agencies.

Table I.6 Main Identified Constraints – Uganda

	Constraint/Issue	Remarks
A	**Water Resources Management**	Until recently, irrigation development has not been important as there had been sufficient rainfall In most parts of the country for crop cultivation. Where water harvesting is needed in the North of the country, access and security for development had not been possible due to continued hostilities.
B	**Agricultural production**	Constraints to increased production vary with location and with livelihood.
	Input unavailability and access to affordable inputs.	Limited access to inputs, such as implements (hoes, ploughs, nets and boats), fertilisers, pesticides, spraying equipment, animal drugs, high yield and resistant seeds, improved breeds, and a variety of improved plant cuttings and seeds.
	Limited access & use of inputs	Barriers to access and utilisation include cost; theft; unavailability in nearby markets; poor quality; and lack of advice. Uganda National Household Survey indicate that in 1995-6, only 1% of poor farmers use improved seeds. About one fifth of better-off farmers use improved seeds in the central, eastern and western regions.
	Poor yields	Declining soil fertility, overuse of small plots, poor methods, erosion and drought conditions. Local people recommend
	Limited access to arable land	Production is constrained by shortages of land, for example in the South West, due to fragmentation, small holdings, population pressure and forced sale of land to meet necessities.
	Control of crop pests and diseases.	The loss of 35-40% of crops to disease and pests severely limits productivity of both food and cash crops – cassava, coffee, banana, tobacco, groundnuts and cowpeas. Poor farmers are unable to cope with diseases and pests because of a lack of money, limited availability of drugs and pesticides, lack of or misguided advice, conflict with Government regulations and officers.
	Lack of skills and knowledge.	Many communities blamed lack of productivity on lack of information, knowledge and skills concerning better methods of food and income-generation (crop production, animal husbandry, fishing methods and alternatives), soil conservation, pest and disease control, marketing opportunities, prices, processing and pertinent government policies and regulations.
	Lack of storage	limits the marketability of perishable goods, such as vegetables, fish and dairy products.
	Limited access to storage and processing facilities.	Lack of grinding mills and fish processing facilities (drying, smoking, salting) close to communities.
	Insecurity	Limits work in distant fields in Northern Uganda, particularly for women; limits commodity availability, prohibits sale of cash crops to external markets due to insecure transport routes, creates difficulties for extension services reaching communities. Fear of theft also limits storage of produce and encourages untimely sale at seasonal low prices.
	Lack of sufficient food.	People relate poor diet with the susceptibility to disease and the inability to work.
	Farmers Organisations	At present there are no effective grassroots/village-based, commercially oriented institutions capable of mobilising the production capacity of small producers for the production of income-generating commodities. The co-operative movement, which was effective in mobilising farmers in this fashion, has not been able to perform this function in the past decade.
	Human Resource Constraints	The majority of Ugandan farmers are illiterate. There is therefore an urgent need to educate and empower them to undertake commercial enterprises efficiently and profitably. Fostering these skills is the surest way to economic growth and overall development.
	Effects of HIV Infection	The Aids epidemic continues to impact negatively on agricultural production. It has the impact of loss of labour, skilled and unskilled for production, research extension services and in policy formulation. It has a direct impact on loss of assets and savings for media care and funeral expenses. Aids mitigation measures therefore, will have a positive impact on agricultural production, household incomes and peoples' welfare.
	On-farm and Off-farm Storage	Post-harvest losses, particularly for food crops, are very high, aggravating the food insecurity problem. In addition to timely harvesting, proper drying, protection from infestation with diseases and pests and storage are critically important and should be introduced. Today, few farmers have well-constructed storage facilities in rural areas. Off-farm storage facilities owned by traders, millers, processors, and exporters are generally lacking and need to be addressed.
	Environmental Degradation	Increase in population pressure, intensive utilisation of land including restricted grazing, soil erosion, deforestation and the drainage of swamps have resulted in considerable environmental degradation and low productivity in many areas of the country. Therefore, environmentally friendly, socially acceptable and affordable technologies should be developed and disseminated for efficient use of natural resources in rural areas.
C.	**Extension/Support Services**	
	Poor quality extension services	Lack of extension staff; lack of facilitation - transport and fuel; insecurity; poor feeder roads; poorly qualified extension officers; corruption; high charges; demotivation of staff due to low and delayed salaries; and use of expired drugs and poor techniques by veterinary officers. Where extension is perceived as beneficial, the service providers are often private (e.g., UNFA), although the membership fee may be restrictive.
		Extension service reach of 5-10% of farmers; Reach to LC I areas – 16%, 33%, 9% and 45% in Central, Eastern, Northern and Western regions
	Lack of information, particularly regarding prices and markets, which would reduce exploitation and improve profits.	Extension services that reach the people and offer advice, information and training on more productive methods, marketing and alternative income generation activities.
	Technology Generation and Dissemination	The major constraints in this category include non-availability of high-yielding technological packages, efficient and cost-effective cultivation technology, low adoption rates of appropriate technology due to weak research, extension and farmer linkages, absence of effective delivery of extension services to farmers.
	Information Constraints	The availability of statistics regarding food crops and export crops is unsatisfactory. Many agencies are involved in the collection and dissemination of agricultural data and they are not well co-ordinated. Organisational and financial as well as managerial deficiencies are acute in most of these institutions. Also the potential users do not know the work of the various agencies. There is therefore an urgent need for the establishment of information services that is acceptable to producers and market operators.
	Marketing	
	Restricted access to markets and market dues	Ready markets are not available for sale of produce and purchase of inputs; long distances to produce markets, impassable roads and lack of affordable transport,]. High market dues for produce sales in general, licences for fisher folk and traders, and livestock slaughter fees, relative to low incomes are said to eat into market profits.
	Low prices and exploitation	Low and fluctuating prices minimise profit due to local poverty, seasonal over-supplies, farmers need to raise cash, exploitation by middlemen or large processing companies

Table I.6 Main Identified Constraints – Uganda (Continued)

	Constraint/Issue	Remarks
	Finance	
	Lack of capital and access to credit and financial services.	limited financial management skills, concentration of credit facilities in urban centres; unfavourable borrowing terms particularly high interest and short, ill-timed repayment schedules.
	Low income and capital for buying inputs, improving or starting new income-generating ventures	Women report that small-scale informal credit for household items and service delivery fees is available to them through revolving savings groups in some communities
	Financial Constraints	At present both investment finance and working capital are the main bottlenecks for smallholder agricultural production. Yet creation and sustenance of a dynamic and productive modern agricultural sector would require on a continuous basis the uptake of new, more productive and high-yielding technology by farmers. Thus creation of viable and sustainable rural financial systems is one of the key elements to agricultural development because most of the productive and high-yielding technologies have to be made available to farmers only as purchased off-farm inputs.
D	**Livestock Development**	
	Lack of proximal water sources for Livestock	Lack of water sources and pastures necessitates migration of cattle herds in search of water and pasture in the dry season. This is particularly striking in Karamoja, where transhumance is associated with cattle raiding in areas to the south.
	Shortage of dry season water	Dry season search for water – lack of proximal dams – leads to migration in search of water and pasture or travelling long distance to source
	Control of livestock diseases.	Livestock diseases, particularly of cattle, and waterweed limiting the fish catch were also raised. Poor farmers are unable to cope with diseases and pests because of a lack of money, limited availability of drugs and pesticides, lack of or misguided advice, conflict with Government regulations and officers, and corrupt fisheries officers.
	Poor pasture	
	Local animal yield and few high yield cows	
	Drugs expensive to treat diseases	Few veterinary extension staff
	Cattle raiding leading to loss of livestock	Cattle-rustling is also a serious problem in the north and east of the country. People are robbed of their savings, in the form of cattle, and their plough animals.
	Loss of oxen.	Failure to plough has restricted the acreage of the land under cultivation, especially in Teso districts where much cultivation is now restricted to hand-hoe.
	Lack of markets	High slaughter and market charges
	Fishing	
	Seasonality and unreliability of fish catch	Decreasing fish size and numbers in Lake Victoria
	Lack of inputs	
	Low prices and profits for small-scale fishermen	
	Lack of ready markets in other districts and in low season	Lack of processing plants and cold storage
	Water weed	
	Poor market facilities	women appear to be most affected by inadequate market facilities, such as sanitation or shelter. Although both men and women are involved in marketing, women may have limited access to the profit.
E	**Irrigation development**	
	Inappropriate designs	Lack of sufficient experience in irrigation and drainage system design
	Poor locations for Small scale Storage dams	Poor siting made worse by political interference
	Poor construction of facilities	Poor quality workmanship and materials & inadequate construction supervision
	vandalism, inadequate maintenance and poor animal watering methods	
	environmental degradation, soil erosion and siltation	
F	**Institutional Aspects**	
	Poor roads and transport networks	Lack of all-weather roads hinders community development, isolates communities and also contributes to poverty. Farmers cannot reach health care facilities, schools, and markets, and services, such as security bodies and suppliers, cannot reach the community.
	Marketing Infrastructure Constraints	Inadequate of physical infrastructure such as feeder roads, communication facilities, power supply and market infrastructure continue to constrain marketing of agricultural produce and investments in rural areas and are responsible for high market transaction costs.
	Land Tenure and Policy	Although a fairly comprehensive Land Act was enacted by Parliament in 1998, it still remains to be implemented to bring about the desired changes in land tenure systems, land policy and land registration as well as land administration improvements. Thus, the constraints of the land tenure systems that are not conducive to the emergence of land markets persist. Also the issue of land ownership and inheritance by women who are key stakeholders in agricultural production has not yet been resolved. In addition, the lack of a centralised land registry results in difficulties in getting land title deeds in rural areas.

.8 LIST OF ACRONYM AND ABBREVIATIONS

Regional

ADB	African Development Bank
AEZ	Agro-Ecological Zones
BCM	Billion Cubic Meters
BP	Best Practice
BoQ	Bill of Quantities
CMI	Community Managed Irrigation
CMIWG	Community-Managed Irrigation Working Group
ASALs	Arid and Semi-Arid Lands
CGIAR	Consultative Group on International Agricultural Research
CIDA	Canadian International Development Agency
CRS	Catholic Relief Service
DRC	Democratic Republic of Congo
DRWH	Domestic Roof Water Harvesting
DSS	Decision Support System
EIRR	Economic Internal Rate of Return
ENSAP	Eastern Nile Subsidiary Action Project
ENTRO	Eastern Nile Technical Regional Office
EWUAP	Efficient Water Use in Agriculture Project
ET_o	Reference Evapotranspiration
EU	European Union
FAO	Food and Agriculture Organisation
FCT	Ferro Cement Tank
FFS	Farmer Field School
GAA	German agro-action
GDP	Gross Domestic Product
GEF	Global Environment Facility

GIS	Geographic Information system
GTZ	Germany Agency for Technical Cooperation
ICARDA	International Center for Agricultural Research in the Dry Areas
ICB	International Competitive Bidding
ICCON	International Consortium for Cooperation on the Nile
ICR	Implementation Completion Report
ICRAF	International Centre for Research in Agroforestry
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IFAD	International Fund for Agricultural Development
ILRI	International Livestock Research Institute
IPM	Integrated Pest Management
IWMI	International Water Management Institute
IWRM	Integrated Water Resources Management.
JICA	Japan International Cooperation Agency
KBO	Kagera Basin Organization
MCM	Million Cubic Meters (Mm^3).
M&E	Monitoring and Evaluation.
NBI	Nile Basin Initiative
NBTF	Nile Basin Trust Fund
NCB	National Competitive Bidding
NELSAP	Nile Equatorial Lakes Subsidiary Action Project
NEPAD	New Partnership for Africa's Development
NGO	Non-Governmental Organization
Nile-COM	Council of Ministers of Water Affairs of the Nile Basin States
Nile -SEC	Nile Basin Initiative Secretariat
Nile-TAC	Nile Basin Initiative Technical Advisory Committee
NPC	National Project Coordinator

NTEAP	Nile Transboundary Environmental Action Project
O&M	Operation and Maintenance
PAD	Project Appraisal Document
PMU	Project Management Unit
PIP	Project implementation plan
PPMI	Public/Private Managed irrigation
PMIWG	Public and Private Managed Irrigation Working Group
PRC	People's Republic of China
PSA	Project Services Agency
PSC	Project steering committee
QCBS	Quality and Cost-Based Selection
RBA	Rapid Baseline Assessment
RWH	Rainwater harvesting
SAP	Subsidiary Action Program
SC	Steering Committee
SSI	Small Scale Irrigation
SIDA	Swedish international Development Agency
SLM	Sustainable Land Management
SVP	Shared Vision Program
SWC	Soil and Water Conservation
TAC	Technical Advisory committee.
TOR	Terms of Reference
UNDP	United Nations Program for the Development
UNOPS	United Nations Office for Project Services
USAID	United States Agency for International Development
WB	World Bank
WFP	World Food Programme
WH	Water Harvesting

WHWG	Water Harvesting Working Group
WUAs	Water Users Associations

Ethiopia

ADLI	Agricultural Development Led Industrialization
AMAREW	Amhara Micro-enterprise Development, Agricultural Research, Extension and Watershed Management
ANRS	Amhara National Regional State
ARARI	Amhara Regional Agricultural Research Institute
AU	Alemaya University
CSA	Central Statistical Agency
COSAER	Commission for Sustainable Agriculture and Environmental Rehabilitation
COSAERT	Commission for Sustainable Agriculture and Environmental Rehabilitation in Tigray
CPC	Cooperative Promotion Commission
DA	Development Agent
DHP	Dry Land Husbandry Project
EARO	Ethiopian Agricultural Research Organization
ENTRO	Eastern Nile Technical Regional Office
EPA	Environmental Protection Authority
ESRDF	Ethiopian Social Rehabilitation Fund
ESTC	Ethiopian Science and Technology Commission
FDRE	Federal Democratic Republic of Ethiopia
GoE	Government of Ethiopia
MERET	Managing Environment Resources to Enable Transition to more Sustainable Livelihoods
MOA	Ministry of Agriculture
MoARD	Ministry of Agriculture and Rural Development
MOFED	Ministry of Finance and Economic Development
MoWR	Ministry of Water Resources

MU	Mekelle University
OCHA	Office for the Coordination of Humanitarian Affairs
OIDA	Oromia Irrigation Development Authority
OSSREA	Organization for Social Science Research in Eastern and Southern Africa
PD	Person Days
qt	Quintal
REST	Relief Society of Tigray
SDPRP	Sustainable Development and Poverty Reduction Program
SNNPR	Southern Nations, Nationalities and Peoples Region
SPFS	Special Program for Food Security in Ethiopia
TBWRD	Tigray Bureau of Water Resource Development
TVET	Technical, Vocational, Educational and Training
WSDP	Water Sector Development Program
WBISPP	Woody Biomass Inventory and Strategic Planning Project

Kenya

LBDA	Lake Basin Development Authority
MOA	Ministry of Agriculture
NIB	National Irrigation Board
KRA	Kenya Rainwater Association
KARI	Kenya Agricultural Research Institute
UH	Upper highland
UM	Upper midland
LM	Lower midland
CL	Coastal lowland

Uganda

DAO	District Agriculture Officer
DWD	Directorate of Water Development
DWO	District Water Officer
GoU	Government of Uganda
JICA	Japanese International Cooperation Agency
LC	Local Council
MAAIF	Ministry of Agriculture Animal Industry and Fisheries
MoWLE	Ministry of Water, Lands and Environment
NAADS	National Agricultural Advisory Services
NARO	National Agricultural Research Organisation
NWP	National Wetlands Programme
PBG	Partially Below Ground
PMA	Plan for Modernisation of Agriculture
TOR	Terms of Reference
URWA	Uganda Rainwater Association
UWASNET	Uganda Water and Sanitation NGO Network
WES	Water and Environmental Sanitation
WID	Wetland Inspection Division

Tanzania

ASDP	Agricultural Sector Development Programme
ASDP	Agricultural Sector Development Project
ASDS	Agricultural Sector Development Strategy
ASPS	Agricultural Sector Programme Support
CHAWAMPU	Chama cha Wakulima wa Mpunga
DED	District Executive Director

DITS	Department of Irrigation and Technical Services
ISID	Institutional Support for Irrigation Development
KADP	Kilimanjaro Agricultural Development Project
KATC	Kilimanjaro Agricultural Training Centre
KATC	Kilimanjaro Agricultural Training Centre
KTFTF	Kibena Tea Fair Trade Fund
MAFSC	Ministry of Agriculture, Food Security and Cooperatives
MATI	Ministry of Agricultural Training Institute
MKUKUTA	Mkakati wa kukuza uchumi na kupunguza umasikini Tanzania
NAFCO	National Agricultural and Food Cooperation
PIDP	Participatory Irrigation Development Programme
RAS	Regional Administrative Secretary
RBA	Rapid Baseline Assessment
RBMSIIP	River Basin Management and Smallholder Irrigation Improvement Project
SAIPRO	Same Agricultural Improvement Programme
SUA	Sokoine University of Agriculture
SWMRG	Soil-Water Management Research Group
SWMRP	Soil-Water Management Research Programme
TANESCO	Tanzania Electricity Supply Company
TIP	Traditional Irrigation and Environmental Development Organization
TPRI	Tropical Pesticides Research Institute
URT	United Republic of Tanzania
VECO	A Belgium Supported project
VEO:	Village Extension Office
SACCOS	Savings and Credit Co-operative Societies
UWAKICHI	Ushirika wa Umwagiliaji Kikafu Chini
CHAUMWE	Chama cha Umwagiliaji Mwega

CHAULU	Chama cha Umwagiliaji Lumuma
WH	Water Harvesting
UWAMALE	Umoja wa Wamwagiaji Maji Lekitatu

Egypt

ARC	Agricultural Research Centre (MALR)
ARC	Agricultural Research Centre (MALR)
BCWUA	Branch Canal Water User Association
CF	Continuous Flow
DRC	Desert Research Center
DRI	Drainage Research Institute (NWRC)
DWB	District Water Board
EEAA	Egyptian Environmental Affairs Agency
GOE	Government of Egypt
GTZ	German Technical Cooperation
HAD	High Aswan Dam
HEZ	Hydro-Ecological Zones
IAS	Irrigation Advisory Service.
IIIMP	Integrated Irrigation Improvement Management Project.
IIP	Irrigation Improvement Project.
L.E	Egyptian Pound
MALR	Ministry of Agriculture and Land Reclamation
MLD	Ministry of Local Development
MED	Ministry of Economic Development
Merwa	Private ditches receiving water from Meska for distribution to the fields.
Mesqa	Private Sub-branch or water courses, receiving water from branch canals
MWRI	Ministry of Water Resources and Irrigation.
NWRC	National Water Research Centre (MWRI).

OFWM	On-Farm Water Management
SWERI	Soils, Water & Environment Research Institute
WRPMP	Water Resources Planning & Management Project
WMRI	Water Management Research Institute

Rwanda

FRW	Rwandan Franc
ISAE	Institut Supérieur d'Agriculture et d'Elevage
ISAR	Institut des Sciences Agronomiques du Rwanda
KIST	Kigali Institute of Science and Technology
MINITERE	Ministère des Terres, de l'Environnement, des Forêts, de l'Eau et des Mines
MININFRA	Ministère de l'Infrastructures
OER	Observatoire de l'Eau du Rwandais.
ONG	Organisation Non Gouvernementale
PDRCIU	Projet de Développement des Ressources Communautaires et des Infrastructures de l'Umutara
PEAMR	Projet de Réhabilitation des Adductions d'Eau en Milieu Rural
PGNRE	Projet de Gestion Nationale des Ressources en Eau
REMA	Rwanda Environmental Management Authority
UNR	Université Nationale du Rwanda

Burundi

AAH	Action Against Hunger
ACORD	Accord de Coopération pour la Recherche et le Développement
ADRA	Adventist Development and Relief Agency
AIBU	Agronomy Institute of Burundi
ANCR	Auto évaluation nationale des capacités à renforcer pour la gestion de l' environnement

	Mondial.
ARP	Austrian Relief Program
ASBL	Association Sans But Lucratif
AZRI	Agricultural and Zootechnical Research Institute
BAD	Banque Africaine de Développement
CARE	Cooperative for Assistance and Relief Everywhere
CBSI	Confidence Building and Stakeholders Involvement
CICR	Comité International de la Croix Rouge
CISV	Communita Impegno Servizio Volontariato
COPED	Coopérative d'Entraide et de Développement
CVHA	Cultures Villageoises de Haute Altitude
DAEPL	Department of Agricultural Engineering and the Protection of Land
DGA	Direction Générale de l'Agriculture
DGHER	Direction Générale de l'Hydraulique et Energies Rurales
DGPAE	Direction Générale de la Planification Agricole et d'Elevage
EC	Equivalent céréales
FAS	Faculty of Agricultural Sciences
FBu	Burundian franc
FCBN	Forum Burundais de la Société Civile pour le Bassin du Nil
GBAE	Green Belt Action for the Environment
GDAE	General Directorate for Agriculture Extension
HCR	Haut Commissariat des Nations Unies pour les Réfugiés
HIMO	Haute Intensité de Main d'Oeuvre
IGEBU	Institut Géographique du Burundi
INECN	Institut National pour l' Environnement et la Conservation de la Nature
ISA	Institut Supérieur d' Agriculture
ISABU	Institut des Sciences Agronomiques du Burundi
LVIA	Lay Volunteers International Association

MINATTE	Ministère de l' Aménagement du Territoire du Tourisme et Environnement
NBD	Nile Basin Discourse
OAP	Organisation d'Appui à l'Auto promotion
OCB	Organisation Communautaire de Base
OHP	Office de l'Huile de Palme
OSC	Organisation de la Société Civile
PAM	Programme Alimentaire Mondial
PAPV	Projet d'Appui à la Production Vivrière
PNLAE	Programme National de Lutte Antiérosive
PRASAB	Projet de Réhabilitation Agricole et de Gestion Durable des Terres
PRDMR	Programme de Relance et de Développement du Monde Rural
PTPCE	Programme des Travaux Publics et de Création d'Emploi
PVC	Programme Vision Commune
REGIDESO	Régie Nationale de Production d'Eau et Eléctricité
SDBS	Socioeconomic Development and Benefit Sharing
SOPRAD	Solidarité pour la Promotion Sociale et l'Aide au développement
SOSUMO	Société Sucrière du Moso
SRD	Société Régionale de Développement
SRDI	Société Régionale de Développement de l'Imbo
WRPM	Water Resources Planning and Management

.9 ANNEX K - REFERENCES

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ANNEX L – TERMS OF REFERENCE - Phase 1

REVIEW, EVALUATE, COMPILE AND PRODUCE BASIN WIDE OVERVIEW ON AGRICULTURAL WATER SECTOR OF NILE BASIN AND RELATED REPORTS ON BEST PRACTICES, STAKEHOLDERS AND FUTURE DEVELOPMENT PERSPECTIVES.

1.0 BACKGROUND

The Nile riparian countries[1] realizing their common concerns and interests over water resources took a major step towards cooperation and established the Nile Basin Initiative (NBI) in 1999. The NBI is guided by a Shared Vision “to achieve sustainable socio-economic development through the equitable utilization of, and benefit from, the common Nile basin water resources.” In order to translate this shared vision into action, the NBI has launched a Strategic Action Program, comprising two complementary parts: 1) a basin wide Shared Vision Program (SVP); and 2) Subsidiary Action Programs (SAPs). The SVP includes a series of technical, socio-economic, confidence building, and training focused projects to be implemented basin-wide to help establish a foundation for trans-boundary regional cooperation and create an enabling environment for investments and action on the ground. The Efficient Water Use for Agricultural Production (EWUAP) project is one of the eight projects of the Nile Basin Initiative’s (NBI) Shared Vision Program (SVP).

Agriculture plays a major role in the lives and livelihoods of most households in the Nile basin countries and contributes significantly to overall economic growth and Gross Domestic Product (GDP). The riparian countries rely on the waters of the River Nile to meet basic domestic needs and for economic growth, and with changing climatic conditions are showing greater desires to exploit the waters of the Nile for development purposes. Agriculture is the dominant user of water resources in the basin but the lavish use cannot be continued and sustained because of growing and competing demands from other sectors. Pressure will soon mount to reduce the amount of water allocated for agriculture because of increasing demands from expanding urban centers, industry, mining, recreation and tourism. The overall productivity of the agricultural sector must be improved meaning sector must produce more crops per given volume of water and land if system is to remain viable. A growing threat of such nature can best be addressed in a comprehensive manner, that is, by finding basin wide solutions.

The Efficient Water Use for Agricultural Production project is designed to be a first step in bringing together regional and national stakeholders to develop a common shared vision on increased availability and efficient use of water for agricultural production.

The EWUAP project intends to provide opportunities by:

- establishing forums to discuss development paths for the Nile basin with a broad range of stakeholders at regional, national, and community levels; improve an understanding of the relationship between water resources and agricultural development; and enhance basin wide agricultural management capacities;
- bringing together regional and national stakeholders to have a common view and understanding on ways and means of improving water use in the sector and develop a shared vision on common issues;
- developing a sound conceptual and practical basis for Nile riparian countries to increase availability and efficient use of water for agriculture; and
- creating a framework to promote basin-wide cooperation and awareness, and build capacity by focusing on the common and basic issues related to water harvesting and irrigation

Key outputs for the project as defined in the initial project documents include:

- Establishment of regional dialogue on Water Harvesting (WH);
- Strengthening of regional consultation on Community-Managed Irrigation (CMI) and enhancement of overall awareness on efficient water-use;
- Strengthening of regional consultation on Public and Private-Managed Irrigation (PMI) and the enhancement of awareness on efficient water-use;
- Exploring and disseminating best practices in water harvesting, community and private-public managed irrigation;
- Building national capacity for a sustainable management of water harvesting and irrigation practices; and
- Providing national level support for agriculture, water harvesting and irrigation policy development.

Currently, the project is conducting national Rapid Baseline Assessment (RBA) of the agriculture sector identifying opportunities, constraints, needs, potential interventions or areas of investment with respect to the theme "Efficient Use of Water for Agricultural Production". This complements information already assembled in country reports by gathering additional information including identification of prospects related to exchange of best practices for water harvesting, community-managed irrigation, and private and public-managed irrigation. The national assessment draft reports are completed for some countries, Ethiopia, Tanzania, Egypt, Burundi, Kenya, Sudan and Rwanda. National assessment works for DR Congo and Uganda have for now been put on hold.

The project would like to engage international consultant support for work in two phases. Phase One of the work will be to review, analyze and evaluate findings of the indicated Rapid Baseline Assessment reports, country wide sector reports available in the riparian countries, and other pertinent local, national, regional and basin wide documents on the sector and as a result, synthesize, compile and produce basin wide reports describing the agricultural sector. Availability of comprehensive summary document giving an overview of the agriculture water sector, identifying key issues, listing and describing best practices, identifying key institutional capacity within the region, and giving ideas for a future vision of the sector would be quite helpful in pinpointing some of the common agenda points that should be considered across the basin.

Phase Two will build on the output of this consultancy in order to help prepare detailed documentation of best practices in water harvesting and community based irrigation and guidelines for their application.

2.0 OBJECTIVES OF THE STUDY

The overall objective of the assessment work is to prepare the Regional Overview of the Rapid Baseline Assessments. The four specific objectives are to:

1. identify the major opportunities and weaknesses in agricultural water management in the basin
2. identify possible high potential best practices in agricultural water management, with particular focus on water harvesting, community based (small scale) irrigation and medium/large scale irrigation, both publicly and privately managed.

3. identify and carry out a preliminary evaluation of national and regional stakeholders, including public and private professional and research organizations, water user representatives and community groups, including women groups and NGOs. A specific set of stakeholders to be analyzed would be basin wide institutions, associations, NGOs and think-tanks with potential to organize capacity building activities and implement field level demonstrations in the areas of water harvesting and irrigation. The EWUAP project may wish to work with some of these institutions in its "linkages and twinning" programme.
4. prepare a preliminary overview of future directions and possible investment priorities in agricultural water management in the basin.

The outputs of the envisaged work will be used to inform partners and stakeholders from Ministries of Agriculture, Ministries of Water and Irrigation, Technical Advisory Committee (TAC), and representatives of NGO, World Bank, donors and Nile Secretariat.

3.0 STUDY LOCATION AND METHODOLOGY

The assessment work (review, analysis, evaluation, compilation, synthesis and documentation) will be carried out in Nairobi, Kenya and in the consultant home largely as a desk study, with some possibility of travel within the basin if strictly necessary.

The study entails review and analysis of country level assessment works, relevant national and regional reports including use of consultant's own experiences and knowledge of sector in the synthesis, compilation and production of technical documents that have basin wide applicability. The assessment work will remain basically a desk review and analysis of documents (Rapid Baseline Assessment reports, sector and basin wide studies, regional sector reports, and other relevant documents dealing with agriculture and agricultural water sectors). The desk work should, if imperative, be supplemented by primary data/information collected from a quick field visit to selected countries, phone interviews with some of the national consultants and stakeholders responsible for the rapid baseline assessment studies of pre-selected countries, and research from various other sources including the internet.

Most of the information required for this desk study is expected to be available in existing documentation, especially the Rapid Baseline Assessments, and in relevant documents produced by major regional and national organizations (research, professional associations, NGOs, donors and others).

However, some further consultation with regional organizations (research institutions, associations, and international NGOs) and professionals and resource persons in the agriculture and water sectors may prove necessary.

The consultant should also contact and communicate with management and resource persons of the Subsidiary Action Programs (Eater Nile Technical Regional Office [ENTRO] and Nile Equatorial Lakes Subsidiary Action Program [NELSAP]) so as to take into consideration their immediate and future needs in the assessment as well as in the other reports.

Some reference materials that are available in the Project Management Unit (PMU) include:

- Project Appraisal Document; Efficient Water Use for Agricultural Production. World Bank, March 2005.
- Project Implementation Plan; Efficient Water Use for Agricultural Production, April 2005.
- Project Implementation Manual; Efficient Water Use for Agricultural Production.
- Rapid Baseline Assessment reports of the agricultural sector of Burundi, Egypt, Ethiopia, Kenya, Rwanda, Sudan and Tanzania.
- Annual reports and work plans of the EWUAP project;
- Annual reports of the Nile – Secretariat;
- Various documents produced by the Subsidiary Action Programs (ENTRO and NELSAP);

Access to public domain websites of some of the international organizations (FAO, IWMI, and other organizations) in order to down load relevant public documents and/or study reports can be arranged from the PMU.

Special consideration should be provided to some reference materials on Integrated Water Resources Management, Watershed Management, Water Harvesting, and Irrigation activities within the Nile basin.

The consultant shall relate findings and recommendations of the basin wide assessment work to project design documents such as the Project Implementation Plan Project Appraisal Document.

4.0 SCOPE OF WORK

The four tasks for the consultants are as follows:

- To summarize from the national RBAs and other available sources of information the physical, technical, economic and institutional problems and challenges in agricultural water management at regional, sub-regional and national levels, and to highlight the implications for the project and for the NBI family
- To identify and prepare an outline overview of best practices in solving the technical, economic and institutional problems and make proposals for the Phase Two work on evaluation of best practices, best practice sites and approaches
- To prepare an annotated list of stakeholder institutions and to make proposals for next steps in the program to identify possible institutions to work with during the life of EWUAP under the "establishment of linkages and twinning activity".
- To prepare a preliminary overview of future directions and possible investment priorities in agricultural water management in the basin.

Based on the background information and the objectives of the basin wide assessment work, the regional Consultant may undertake some or all of the following or other activities agreed with EWUAP management:

I. Review, analyze and evaluate relevant documents or reports including Rapid Baseline Assessments describing the agriculture sector (rain-fed and irrigated) in the Nile basin paying special attention to the issues of water harvesting, irrigation, efficient water use, and productivity;
II. Identify weaknesses, opportunities, constraints and needs of the agricultural sector of the Nile basin countries by focusing on productivity and efficient use of water under rain fed and irrigated conditions. The regional Consultant is expected to identify and highlight potential interventions (soft and hardware types) for immediate consideration;
III. Prepare a broad and generalized background information on the agricultural water sector of the Nile basin, identify constraints, weaknesses, and opportunities by highlighting the prominent role of water management practices (water harvesting, storage, diversion, conveyance and utilization) in the sector;
IV. Identify key players in the sector in terms of institutions at the national and/or regional levels and show their relationships;
V. Identify and incorporate in the assessment report, information on associations, water use groups, international NGOs and others involved in the provision of services related to water use and irrigation in the basin;
VI. Based on desk review, analysis, and synthesis of available relevant literature and documentation and consultant's own personal experiences and knowledge in the sector, identify, describe and compile preliminary information on best practices in water harvesting, community based, and public/private managed irrigation systems that are adaptable and relevant to the Nile basin;
VII. Identify and profile/describe potential organizations and site(s) across the Nile basin to serve as center(s) of excellence for exchange of knowledge and experiences on best practices in each of the project components (WH, CMI, and PPMI);

VIII. Identify and record constraints or existing conditions that influence and affect promotion and adoption of best practices and technologies;

5.0 DURATION OF ASSESSMENT WORK AND DELIVERABLES

The proposed assignment will be carried out in a period of two months (up to 45 working days in October up to December 2007). The Consultant, to be selected on a competitive and transparent system, will conduct the basin wide assessment of the agricultural sector and produce specified deliverables in accordance with the time frame shown below.

- A schedule of events showing details of the processes and activities to be undertaken including the time frame required for the assessment work (desk review, field verification, consultation, etc): 8 October 2007;
- A written request for field trips/visits or phone communications identifying gaps and limitations, countries to be visited and individuals to be contacted including a draft of a questionnaire to be used in a data/information gathering process: 2nd week of October 2007;
- A First Draft Interim Report (hard and soft) of the basin-wide overview on the agriculture water sector of the basin countries for review and comments: End of October 2007;
- Power point presentation of major findings/recommendations of the overview in a workshop to be organized by the PMU a week after the submission of the Draft Interim Report to TAC and SC members, Working Groups, NPC, PMU senior experts and other stakeholders in order to discuss issues of main concern and receive some feedback information: 2nd week of November 2007;
- A First Draft 'Concept Note' outlining sector development perspectives for agricultural water in the basin and the kind of support expected from a new NBI organization: 3rd week of November 2007;
- A First Draft Report identifying best practices and adopted technologies in the areas of Water Harvesting and Irrigation that are widely used in the Nile basin countries: 3rd week of November 2007;
- A First Draft Report of identified stakeholders with evaluation of possible organizations with which EWUAP could work under its "establishment of linkages and twinning activity". (Format and content to be discussed with Lead Specialist during 1st week of June 2007): 3rd week of November 2007;
- Final Draft Reports of the **basin wide overview of the agricultural water sector, concept note on sector development perspectives, report on best practices related to project components, and report on stakeholders and possible partners for twinning** to the PMU. The Final Draft Reports will be submitted to the PMU in both hard and soft copies [word format electronically (CD) and bound hard copies]: 4th week of November 2007;

6.0 EXPECTED OUTPUTS

A comprehensive basin wide assessment report/document on the agriculture and agricultural sector of the Nile basin comprising:

- An overview of the agricultural water sector in relation to efficient use of water for agriculture in the basin, covering legal and institutional frameworks identifying weaknesses, needs, constraints, and opportunities, recommending project ideas/components (new or additional), and pinpointing priority areas of investment/intervention.
- A preliminary report on best practices and adopted technologies in the areas of water harvesting and irrigation that are widely used in the Nile basin countries.
- A report on identified stakeholders that will (a) list key stakeholders including professionals, associations, research institutions, societies, institutions of higher learning, community organizations, NGOs, women groups, and others associated with the three project components and/or others identified during the assessment; (b) list regional institutions or organizations

actively involved in the sector and more so in the areas of efficient water use, water harvesting, and productivity of land and water and their capacities; and (c) give some basic information/facts and make a preliminary evaluation of at least one regional center of excellence specialized in each of the areas of water harvesting, community-managed irrigation, and public/private-managed irrigation that may be considered as an EWUAP partner in its "linkages and twinning programme" and can be used for training, field visits and/or study tours.

- A short note on sector development perspectives indicating future directions and/or possible investment priorities in the agricultural water

Each report should not exceed 40 pages using font sizes of 10 - 11. Consultant can provide as much information as possible using Annexes and/or Attachments for which there are no limits. Consultant is encouraged to provide lists/rosters of stakeholders, reference materials, persons contacted, offices/sites visited, TOR, and related as part of the Annexes;

7.0 MONITORING AND SUPERVISION

The regional/international Consultant will work in close collaboration with the Project Management Unit and, hence, in collaboration with the Lead Specialist and the Regional Project Manager. He will consult and liaise with National Project Coordinators, Steering Committee members and other relevant stakeholders. Overall, however, the Consultant will work under the overall guidance and supervision of the Regional Project Manager of the EWUAP project. Members of Working Groups for WH, CMI, and PPMI might also be available and might offer invaluable advice and assistance.

8.0 METHODOLOGY AND STANDARDS

The Consultant will be expected to employ the most effective methodology to achieve results. This study will basically involve review and analysis of assessment reports, if need arises, collection and compilation of existing information from relevant sources (Ministries of Agriculture, Water, and Environment, Research Inst., NGOs and the private sector). The Consultant will primarily focus on secondary data sources with an option to gather additional primary information if found absolutely necessary in terms of verifying and/or substantiating secondary data. In addition the Consultant will be expected to:

- Design and use questionnaires that are realistic and capable of capturing accurate information,
- Collect most of the data from review and analysis of existing secondary sources of information, in this case, country assessment reports,
- Use credible support staff in data and information collection,
- Prepare clear, concise and focused reports,
- Ensure reports and necessary documents are delivered in time and as per the agreements,
- Communicate any unforeseen deviation from the agreed consultancy plan immediately, with clear justifications and proposed remedial course of action

9.0 REFERENCE DOCUMENTS

The following documents would be availed as reference background material:

i. Project Appraisal Document(PAD);
ii. Project Implementation Plan(PIP);
iii. Rapid Baseline Assessment (RBA) reports produced by national consultants in each of the Nile basin countries
iv. Country reports/documents prepared in relation to the design and development of the SVP projects that might be available with TAC and/or national NBI office.
v. Integrated Water Resources Management strategy developed by the International Water Management Institute (IWMI), FAO, WB, ADB, and others to be downloaded from public domain websites of the respective organizations.
vi. Other relevant documents

10.0 TIME FRAME

The proposed assessment work would commence o/a the beginning of the 1st week of October 2007 and be completed o/a the end of November/December 2007 or (Estimated up to 45 working days).

11.0 SELECTION AND REMUNERATION

Short-listed candidates from CVs and a list obtained from the sources indicated in Section 5.0 above will be provided with a copy of the TOR and will be officially requested to submit Expressions of Interest or short proposals (technical and financial) responding to the issues identified in the TOR. Submitted Expressions of Interest or proposals will then be reviewed and evaluated by PMU staff and selections and recommendations forwarded to the UNOPS PSU for negotiation and award of contract.

The Consultant will be remunerated in accordance with the standard official UNDP rates for International Consultants. Reimbursable expenditures expected in relation to the undertaking of the assessment work will have an upper limit and as a result should be discussed and resolved during contract award negotiations.

Based on outstanding performance and at the discretion of the Regional Project Manager, it is envisaged that his consultancy contract could be amended to cover Phase Two activities.

12.0 QUALIFICATIONS OF THE CONSULTANT

- Advanced degree in water resources management, agriculture, environment, or related fields of study;
- Extensive experiences in program development, water harvesting, irrigation (small and large scale), watershed management, crop and livestock production;
- At least ten years of experience in program/project development in the agricultural water sector (production, soil & water management, environment, and natural resources management) with 3-4 years of work experience in regional/international development and/or consultancy services;
- Excellent knowledge of the broader agricultural issues (efficient use of water, watershed management, productivity, and general environmental issues) in the Nile basin and be familiar with the basin or most countries in the basin;
- Fluency in spoken and written English; knowledge of French an added advantage.
- Excellent presentation and communication skills.
- Excellent analytical skills.
- Good computer skills.
- Experience in having worked with/for an international or donor organization is an advantage.