Efficient Water Use for Agricultural Production (EWUAP) Project

Best Practices and Guidelines for Water Harvesting and Community Based (Small Scale) Irrigation in the Nile Basin

PART I – BEST PRACTICES IN COMMUNITY BASED (SMALL SCALE) IRRIGATION

by

Ian McAllister Anderson

Martin Burton

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ANDERSON
Irrigation & Eng. Services Limited
Potters Farm, Bethersden
Nr Ashford, Kent.
England. TN26 3JX
Irrigltd@aol.com
Martinaburton@btinternet.com

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Indicative Exchange Rates (5 January 2009)

Country	Currency	Rate to US$
Burundi	Burundi Franc (FBu)	1215
DRC	Congo Franc	557
Egypt	Egypt £	5.52
Ethiopia	Ethiopian Birr	9.96
Kenya	Kenya Shilling	78

Rwanda	Rwanda Franc	560
Sudan	Sudan Pound	2.19
Tanzania	Tanzania Shilling	1,330
Uganda	New Uganda Shilling	1,975

Acronyms and Abbreviations

ADB	African Development Bank
AEZ	Agro-Ecological Zones
BCM	Billion Cubic Meters
BP	Best Practice
BoQ	Bill of Quantities
CBSSI	Community Based (Small Scale) Irrigation
CGIAR	Consultative Group on International Agricultural Research
CIDA	Canadian International Development Agency
CMI	Community Managed Irrigation
CMIWG	Community-Managed Irrigation Working Group
ASALs	Arid and Semi-Arid Lands
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
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)

<u>Note</u>: *For Acronyms by Country, see Annex J. Agricultural Water in the Nile Basin – An Overview, Final Report, Ian McAllister Anderson, April 2008.*

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 to 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 area
Valley tank	On stream valley excavation of a reservoir for trapping and storing surface runoff from a catchment 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. 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.	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.
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	$\frac{\text{Total area cultivated during the year}}{\text{Command area}}$	
Irrigation intensity	Number of irrigation seasons per annual cycle	
Delivery performance ratio or Management performance ratio	$\frac{\text{Actual supply discharge}}{\text{Target discharge}}$	
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	$\frac{\text{Volume of water delivered (to tertiary unit)}}{\text{Volume of water diverted/pumped from source}}$	
Distribution efficiency	$\frac{\text{Volume of water received at field}}{\text{Volume of water delivered (to tertiary unit)}}$	
Field application efficiency	$\frac{\text{Volume of water needed by crop (crop } ET_P \text{ - effective rainfall)}}{\text{Volume of water received at field}}$	
Irrigation system efficiency	$\frac{\text{Volume of water received at field}}{\text{Volume of water diverted/pumped from source}}$	
On-farm efficiency	$\frac{\text{Volume of water stored in the root zone}}{\text{Volume of water received at field}}$	Expresses role of soil water holding capacity
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)	$\frac{\text{Yield of harvested crop}}{\text{Consumptive use}}$	Consumptive use comprises rainfall, irrigation, capillary rise and moisture depletion
Economical crop water productivity (US$/m3)	$\frac{\text{Value of harvested crop}}{\text{Consumptive use}}$	

References

a/. Bos and Nugteren (1974; 1990)

b/. ICID (1978)

c/. IWMI (1987; 1993)

d/. Boss, M..G.; Burton, M. A.; Molden, D.J.; (2005)

e/. Proceedings of EWUAP Inception Workshop; Best Practices; Nov. 2007.

f/. FAO Irrigation and Drainage Paper 56

The information presented in this report reflects the views of the Consultants 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 published data obtained from international organisations and from the internet. This has been supplemented with the knowledge and experience of the Consultants who have worked in most of the Riparian states at some time over the last 35 years.

Executive Summary for CBSSI

The major farming systems of the Nile Basin correspond with the main agro-ecological zones, with most rural populations engaged in agriculture occupying the higher potential sub-humid and humid zones. Eighty percent of the upper Nile Basin's poor live in rural areas, and depend largely on agriculture for their livelihoods. Food and cereal crop production will need to expand rapidly in coming years in order to keep pace with population growth, as well as to alleviate poverty. However, despite increased investments and actions within the Nile Basin in the past, , studies reveal that most countries have a limited capacity to absorb shocks such as drought, floods and high external prices. As a result, in spite of efforts to establish long-term sustainable strategies, many interventions have been of a short term nature (so called quick impact projects), without adequate longer term support. Currently, the low agricultural production levels in all the riparian countries, is insufficient to sustain their populations. This is further exacerbated by the recent rises in the cost of energy, including the global market price of wheat, which have increased their vulnerability. Additionally, population growth has exceeded crop production and with limited available arable land, there is increasing competition for jobs and high unemployment in rural areas. There have been considerable efforts by the government and private sector to recycle drainage water and reuse treated wastewater, however, the water shortage within the Nile Basin remains a critical problem.

Issues that link agricultural water development to poverty reduction and growth have not been clearly appreciated, and this has been one of the reasons for underdevelopment of the subsector. For instance, insufficient regular investments, inadequate involvement of farmers and support to them, and ineffective and changing central state management, has resulted in the poor performance of many traditional and state irrigation schemes. All these aforementioned constraints are characterised by low crop production (similar to rainfed lands), limited water use efficiency and poor irrigation infrastructure. For successful interventions, a longer term commitment and better understanding by the Governments and Donors is needed to reduce the constraints facing farmers living in marginal areas. Extensive research suggests that most of the decision-making continues to be hampered by a lack of an experienced number of technical professionals. Thus, water sector strategies have not fully addressed the problems experienced by both irrigated and rainfed farmers. Several over-riding issues have emerged such as limited community involvement, poor support from extension services, inadequately trained and equipped professionals, and a lack of market linkages.

Against this backdrop, the returns to investments have been far less than anticipated. Furthermore, the relatively high cost of irrigation systems, has deterred donors and financiers from supporting new community based (small scale) irrigation systems. Yet, the money invested in agricultural water can contribute to agricultural growth and reduce poverty directly by (a) permitting intensification and diversification on already developed land to raise farm outputs and incomes; (b) increasing on-farm employment, and thereby discouraging migration to urban centres in search of better wages; and (c) expanding the availability of food in local markets, leading to a reduction in local food prices and an improvement in real net incomes.

There has been a growing need for improved productivity from irrigation schemes and a subsequent increase in crop production, which would also ensure better development and management of the diminishing water resources. Improvements in CBSSI offer great potential, and this collection of reports has shown that there are many experiences that can and should be utilised more widely within the Nile Basin. For example, WUA formation and empowerment is a critical issue in many of riparian countries. There is evidence of successful case studies and proven arrangements within the region, including accompanying legislative frameworks that could be of considerable use and benefit to others. As many of the capital costs are now sunk, attention must be given to making these systems perform. Low productivity is closely related to unreliable water supplies, low input use and difficulty in accessing profitable output markets and will also reflect the lack of incentives for change by most subsistence farmers. Expansion into new areas to increase production, particularly using a blue print approach has not been a successful strategy. As a result, priority by all the riparian countries needs to given to getting existing irrigation systems and schemes in order. , Nevertheless, the provision of irrigation water alone will not guarantee increased productivity, as any support afforded must be long-term, in order to overcome the wide variety of constraints experienced by irrigation farmers. More incentives need to be given to farmers for the improved access to inputs, , reasonable returns and access/entry into adequate and appropriate markets. The most important factor being ownership by the communities who will be utilising the schemes, and their adoption of responsibility for operation and maintenance (O&M). Ineffective O&M of irrigation developments has been one of the main weaknesses of the irrigation systems in the Nile Basin. In spite of the considerable efforts made to train and involve farmers, many have failed to meet donor expectations. This is due to the insufficient funds garnered from local communities once project support has been removed, which can only meet reactive maintenance needs. As was demonstrated in the overview of the Nile Basin[1], there have been good and successful efforts to involve the beneficiaries much more in the operation and maintenance of schemes, and to some extent in the planning. However, a more concerted effort must be made, which includes the institutionalisation of approaches in national guidelines and documentation. Hence it is important that before upscaling, the examination of techniques be carried out under practical field conditions, and at an appropriate scale. This would help determine the most suitable arrangements considering the different communities, local site conditions and access to markets. All in all, the support for irrigation needs a longer-term commitment to ensure that the infrastructure is properly constructed, utilised and managed. Many sites for irrigation in remote areas within the Nile Basin are served by poor road and communication infrastructure. Consequently, 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. It is essential that the Nile Basin governments take this into careful consideration, to ensure that there are incentives for those prepared to become involved in the more remote rural areas. Currently, great success has been achieved by 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.

The upscaling of Community Based (Small Scale) Irrigation (CBSSI) in Africa requires a conducive enabling environment, as well as a number of well trained professional staff and technicians at all levels, which are equipped with guidelines and manuals appropriate to their level of education. The literature should be practical, extensive, as well as comprehensive so that all professional staff concerned, are able to answer all questions and queries put across by the communities. This includes meeting the technological requirements of the CBSSII intervention. In addition, it is necessary to have regular and systematic training, both in the public and private sector. The above-mentioned guidelines play an important role in the development of toolkits for governments and professionals in the Nile Basin countries. Although a wealth of technical information on CBSSI already exists, there are insufficient mechanisms for disseminating this knowledge and experience across the Basin and between practitioners in each country. There is an increasing need for governments to be actively engaged in the knowledge transfer, and utilisation of experiences for wider upscaling throughout the Basin. This does not mean interference by government, but longer-term and more coordinated political commitment to the approaches.

There are a good number of successful examples of community based small-scale irrigation schemes in each of the Nile Basin countries. Nevertheless, the encouragement of the upscaling of best practice 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 farmers' 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 upscaling the improvement of productivity of existing irrigation systems. As a result, instead of introducing pre-packaged hardware systems, developers should apply the best principles of efficient irrigation, and utilise indigenous skills and materials. Their overall aim being the adaptation or redesigning of flexible technology, which will suit the prevailing local conditions and requirements, rather than simply transferring western technology to the irrigation farmers.

The guidelines in this report aim to provide basic information in the form of a Toolkit on the Best Practices that should be adopted, and the factors that need to be taken in consideration in Community

[1] Ian McAllister Anderson, April 2008.

based Small Scale Irrigation. It includes links to relevant and more detailed manuals, including references and sources of information and data. An extensive review of existing materials at country, basin and international level has also been carried out. In addition, the consultants have built upon the research and discourse between country officials in government, NGOs and Donors/International organisations, in support of the EWUAP study on best practices and Agricultural Water in the Nile Basin – An Overview. A number of guidelines and design manuals exist for improving irrigation with most relating to project interventions. This Toolkit has endeavoured to recognise these documents, and link the reader to the most important references.

This final report on Community Based (Small Scale) Irrigation has been prepared following the last workshop held in Nairobi in November 2008 to present the findings, ideas and discuss the way forward. It comprises of two volumes:

<u>Community Based (Small Scale) Irrigation Report</u>

Part I: Best practices in Community Based (Small Scale) Irrigation.

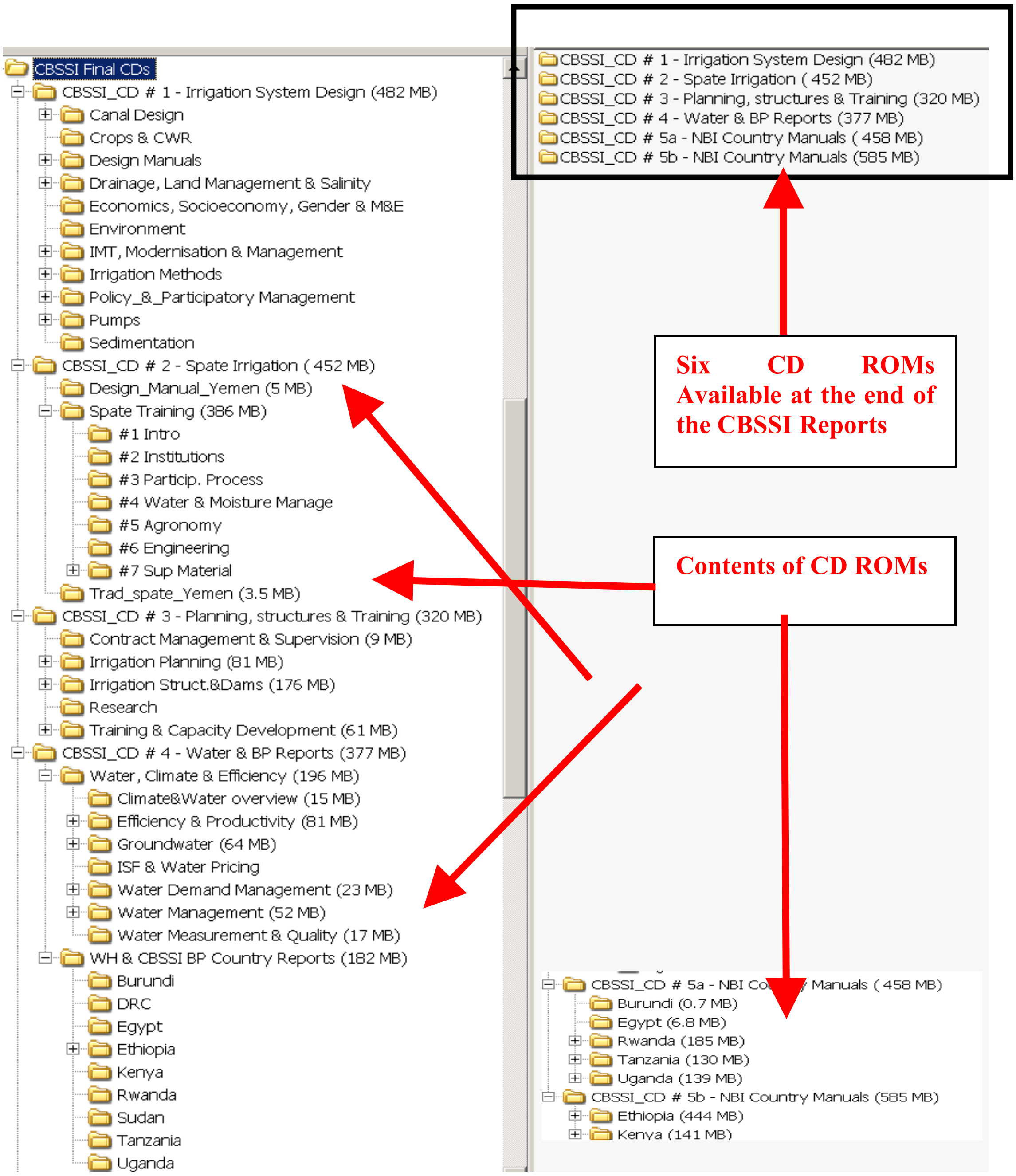
Part II: Guidelines for the Implementation of Best Practices in Community Based (Small Scale) Irrigation.

Part I comprises of 12 Chapters, and provides an overview of the Best Practices (BP) in Community Based (Small Scale) Irrigation (CBSSI) in the Nile Basin countries, highlighting the constraints and options for improvement (Chapter 2 and 3). Conditions within the Nile Basin vary considerably and this is reflected in the discussion of the features of Community Based (Small Scale) Irrigation best practice in the Nile Basin (Chapter 3). In Chapter 4 and thereafter, the findings of best practices and the specific identified sites in each country are discussed. The report attempts to bring data from the individual studies into a common format, although this has not been possible in all cases due to the varied and incomplete results and presentations provided in some cases. The results for each country are available on CD ROM #4 provided with this set of CBSSI reports (see page 14 below). In reports, the National Consultants used the standard forms provided to them to summarise the details of the best practice sites that they identified. This enables the interested reader to understand what has been identified as BP in CBSSI in each country, and whether there are interventions or approaches that would be of common interest. It must be emphasized that the results build upon the data and information provided by those people working within the sector in the Nile Basin and therefore represents their understanding of the practices and issues involved. The practitioners are fully aware of the conditions and constraints under which the beneficiaries have to work, including reasons for the successes and failures. The same group of professionals have articulated their needs and concerns and these are reflected in the contents and details provided in the second volume, Part II: Guidelines.

In Part II, which is provided in a separate volume, appropriate guidelines for the implementation and application of most of the described and documented best practices are given. The extensive information provided will assist the practitioner in understanding the processes to be followed to achieve BP, and that need to be taken into consideration when planning, designing and implementing Community Based (Small Scale) Irrigation projects. They have been written with the intention of providing senior professionals in each Nile Basin country with sufficient information, to enable them to produce or update practical guidelines for their own target groups. Whereas some readers may find that there is not enough information for them, it is important to realise that the guidelines are aimed at people with a technical grounding and professional training in CBSSI or an associated field, and with practical experience in the implementation of the same. It is behoves these professionals to assist those with less experience to adapt the aforementioned guidelines.

Significant and numerous useful references are included in the text, with links to other documents and manuals that can assist the reader with planning, design, construction and MOM. Each reader can take what they need from the documents to supplement their knowledge and information. Accompanying the reports are six CD ROMs that contain a wealth of published information, and many of the reports cited in the text (see Table E.1 below). The first CD contains reports, references and information that relates to the design of Community Based (Small Scale) Irrigation, existing manuals and many other topics. CD ROM #2 is dedicated to Spate Irrigation. CD ROMs #3 & #4 contain other complementary reports, references and information as all could not be contained on one CD ROM. Also included on this CD ROM are copies of the Best Practice reports on WH and CBSSI, completed by the National Consultants. The remaining two CD ROMs (#5a & #5b) contain additional information and existing manuals for those countries where these data were made available. It is essential that readers appreciate that the production of guidelines is a dynamic process with feedback and updating of material an essential feature. They should not be cast in stone but should be flexible enough to adjust to the changing environment.

Table E.1 Contents of Accompanying CDs for Community Based Small Scale Irrigation Guidelines (CBSSI)



Part III provides suggestions for both WH and CBSSI on how to improve upon the performance of both. WH and CBSSI are very closely connected with common constraints and requirements for further support. Both need to be treated in an integrated manner that extends from catchment protection, down to use of available water resources. The proposals presented in the report will need to be developed into viable projects for implementation either by national governments, or through the basin wide projects implemented under the successor to EWUAP, the institutional support project (ISP).

1 INTRODUCTION

This final report on identified best practices in Community Based (Small Scale) Irrigation has been prepared in response to terms of reference "*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. Phase II*[2]*"*. The implementation approach was set out in the Proposal for the Consultancy services[3] , and the current documents were completed following the final workshop held in Nairobi in November 2008. The report has been structured as follows:

Community Based (Small Scale) Irrigation Document/Report
Part I: Best practices in Community Based (Small Scale) Irrigation.
Part II: Guidelines for the Implementation of Best Practices in Community Based (Small Scale) Irrigation.
Part III: Action plans for possible investments to be considered by the SAPs.

Part (III) has been finalised following the final workshop and builds upon the ideas, suggestions and priorities of representatives from each Nile Basin country[4]. The active participation, involvement and ownership of those who attended has been greatly appreciated, and contributed to the final product that has incorporated recommendations made in the plenary discussions[5].

This Part I CBSSI report is complimentary to the series of reports covering both water harvesting[6] and small scale irrigation. It has been prepared with a similar approach, and is intended as a **stand alone document.** Some repetition will inevitably occur as water harvesting and irrigation are closely interlinked. In addition, both Water Harvesting and Community Based (Small Scale) Irrigation (CBSSI) assignments are covered under common terms of reference.

1.1 Purpose

The overall objective of this consultancy, as set out in the terms of reference, is to "*identify, describe and document in detail most of the best practices in water harvesting and community based (small scale) irrigation, and prepare the necessary guidelines for application of the described and documented best practices within the Nile Basin countries. The end product of the consultancy is a handbook of best practices, profiles of best practice sites, a guideline for the implementation of the best practices, and targeted action plans focusing on investments to be considered by the SAPs.*

The outputs of the envisaged work will be used to inform partners and stakeholders from the Ministries of Agriculture, Ministries of Water and Irrigation, Technical Advisory Committee (TAC), SAPs, representatives of NGO, World Bank, donors and Nile Secretariat. Most of all, however, the products (in various forms) will be used to inform and guide beneficiaries and/or practitioners at community and household levels, so that proper use of the practices will eventually contribute to efficient use of water in the sector, ultimately leading to the increased availability of water.

This assignment plays an important role in assisting and contributing to achieving some key outputs from the **Efficient Water Use for Agricultural Production (EWUAP) Project**. These EWUAP outputs were defined in initial project documents and repeated in the terms of reference to include:

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[2] TOR_BPPBS_PHASEII_Dec2007_rev_PMU_Final.doc
[3] IMA_Proposal_for_Phase_2_Final_18Feb08.doc
[4] Electronic copies of all draft documents (Parts I, II & III) for both Water Harvesting and Community Based (Small Scale) Irrigation were provided to representatives from each Nile Basin country prior to the workshop with one complete hard copy provided to each country on completion of the workshop.
[5] Proceedings of Final Regional Workshop (Workshop 2) – Best Practices for Water Harvesting and Community Based Small Scale Irrigation. Orodi Odhiambo. EWUAP. Nairobi. December 2008.
[6] Water Harvesting Document/Reports: Part I - Best practices in Water Harvesting; Part II - Guidelines for the Implementation of Best Practices in Water Harvesting; Part III - Action plans for possible investments to be considered by the SAPs. Ian McAllister Anderson, Dr Martin Burton, October 2008.

- Establishment of regional dialogue on Water Harvesting (WH);
- Strengthening of regional consultation on Community Based (Small Scale) Irrigation 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.

1.2 Background

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[7]. It was designed as a first step to bring together stakeholders within the Nile basin to develop a common vision, on the increased availability and efficient use of water for agricultural production. 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.

In support of the above, the EWUAP project engaged an international consultant[8] to carry out two assignments over a period of about one year. Phase 1 reviewed, analyzed and evaluated the findings of the Rapid Baseline Assessment reports produced by National Consultants from most of the riparian countries, together with other pertinent local, national, regional and basin wide documents on the sector. The result was a report[9] providing a basin wide view of the agricultural sector in the Nile. This in turn brought forth for a future vision of the sector, aimed at assisting in the identification of a common agenda that could be considered across the Basin. Phase 2 has attempted to build on these findings to produce in this group of CBSSI reports, detailed documentation of best practices in Community Based (Small Scale) Irrigation and guidelines for their application. The work described in this and accompanying reports follows the approach and scope of work presented in the Consultants proposal[10] that responded to the terms of reference divided by EWUAP[11]. Likewise, the scope of work has relied on the outputs of the reports of the national consultants engaged by EWUAP, and supported by their in-country peers and working groups. Although the international Consultants have used their extensive knowledge of the Nile Basin countries to expand upon and complete the information provided, the sites selected and descriptions included have rested solely on the information agreed by the national validation workshops held in each country.

1.3 Approach

This report has been mainly a desk study, with key visits to selected upper Nile Basin countries (Kenya, Uganda, Tanzania, Ethiopia, and Rwanda)[12]. These were used to discuss with country officials the findings of Phase 1, the range of best practice sites chosen by the National Consultants, and the results of the validation workshops. In addition, requested data collected by NPCs was

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[7] 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/)

[8] Ian McAllister Anderson supported by Dr Martin Burton under Phase 2.

[9] Agricultural Water in the Nile Basin – An Overview, Final Report, Ian McAllister Anderson, April 2008.

[10] Nile Basin Overview on Agricultural Water Sector, Best Practices and Future Development Perspectives, Proposal for Phase 2, Ian McAllister Anderson. Anderson irrigation and engineering services Ltd, 18 February 2008.

[11] Efficient Water Use For Agricultural Production (EWUAP) Project, Terms Of Reference (TOR) 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 Perspective. December 2007.

[12] The time scale and budget for the assignment did not permit travel or extensive field trips to all Nile Basin countries.

reviewed, and a discussion with relevant key players carried out regarding the design manuals used for CBSSI, and the requirements and proposed approaches to be followed. The Consultants have built upon the research and discussions carried out in support of the EWUAP study on best practices. The basis for the selection of each best practice site in each member country relies upon the information and details presented in the reports from each national consultant, which was agreed upon with respective governments and key national professionals in the validation workshops.

The original time scale set out in the Consultants proposal was not realised, as the signed agreement was not received until the end of March 2008. Preparatory work on the assignment was therefore delayed until April comprising of (i) assistance provided to EWUAP/PMU on guidelines for validation workshops to be carried out in March in each member country, (ii) guidelines for the National Project Coordinators (NPCs) in each country relating to further data collection on manuals and guidelines currently in use and (iii) preparations for the field visits to be carried out to selected Nile Basin countries.

Field visits took place in May/June 2008, and were followed by a period of data review and report drafting prior to the first Regional Workshop (Workshop 1) held in August 2008[13]. Delays occurred during this period due the lengthy time needed by member countries to provide the requested data, to complete the validation workshops, and for the Governments to reach agreement with the National Consultants on the Best Practice sites selected. Similarly, information on best practices was not available from DRC and Sudan until August 2008.

During the Regional Workshops, the consultants presented the ideas, findings and approaches to be followed as well as the final drafts of the guidelines. The proceedings of this workshop are presented separately[14]. After the first workshop, the consultants continued the detailed work on the preparation of the guidelines for CBSSI, taking on board the comments received from EWUAP, as well as some of the participants in the workshop. This lead into the next Regional Workshop (Workshop #2) held in Nairobi in November 2008, at which the final drafts of the completed guidelines for both WH and CBSSI were presented and discussed, along with proposals for possible investments to be considered by the Subsidiary Action Programs (SAPs). In addition, the Consultants have utilised the very productive discussions in the finalisation of the CBSSI reports, taking into consideration the comments and suggestions received from participants and EWUAP. Throughout the assignment, close contact was maintained with EWUAP and following the field visit, a position paper was prepared setting out the longer term perspectives[15]. During the field visit, discussions were held with the NBI secretariat and World Bank Task Team Leader[16] , on the status and preliminary findings of the assignment. Contact has been maintained with the consultants working on the Large Scale Irrigation (LSI) assignment, although the two time scales were not synchronised. A joint meeting was held in London on 27th June 2008, which was attended by Mr C. Ward from the World Bank. . The status and methodology used in each consultancy were discussed along with the issues arising during implementation and the approaches to be followed to complete the outstanding work.

1.4 Overview

Examination of the available material and manuals on CBSSI within the Nile Basin has shown that a lot of relevant data is available, however, the utilisation and dissemination of the knowledge is not widespread, and does not withstand institutional change. Each riparian country has its own selection of manuals and reference material, and most of it has been compiled as a result of donor assistance. In many cases efforts have been duplicated. Studies reveal that governments with donor support have concentrated more on CBSSI rather than water harvesting. This has in part been due to the larger contiguous blocks of traditional and small scale irrigation that has been practised widely for a number of years, and where scope existed for improvement and expansion. Regional organisations such as the

[13] Originally planned for the end of June 2008.
[14] Proceedings of Final Regional Consultation Workshop on Best Practices, Guidelines and Manuals for Water Harvesting and Community Based Small Scale Irrigation, Nairobi Safari Club 13th-15th November 2008, KENYA, and Nairobi, Kenya. Orodi Odhiambo, EWUAP Training Consultant.
[15] Final Notes on Field Visits.doc
[16] Mr John Collier.

International Water Management Institute (IMWI) have carried out research and support to projects and studies that have also involved NGOs and academic institutions. This has been especially noted in the context of community participation and the improvement of Water Users Associations (WUAs). In spite of all this support, there has been limited improvement in the knowledge dissemination and sharing of ideas both in the countries and regionally. Although some transfer has taken place with high level practitioners, the results have not been fully translated down to the lower level practitioners and incorporated into routine practice within the riparian countries. Hence, the EWUAP project has recently produced (as an input to this assignment) a series of country best practice reports prepared by National Consultants in all countries. The results of these studies have in most cases been validated by the National Committees[17].

Only the data and information made available to the consultants from the National report production and workshops by the agreed deadlines and TOR, has been put to use This information has been supplemented by regionally and internationally available data, and the consultants own detailed knowledge of the Nile Basin countries and Community Based (Small Scale) Irrigation. Inevitably additional data and information will become available, and it is important that this current document is seen as a dynamic means of informing and updating practitioners in the Nile basin countries, rather than a definitive "catch all" document.

Evidently, the review of data and information carried out during the first part of this assignment has shown that clearly that there is no need for more manuals or guidelines for Community Based (Small Scale) Irrigation is sufficient. Extensive work has been carried out by the Food and Agricultural Organisation of the United Nations (FAO) both regionally and internationally, concerning most aspects related to CBSSI. Additional studies and projects such as Improving the Performance of Irrigation in Africa (IPIA)[18] in Kenya have added to this. Priority should be given for filling identified gaps in the national materials, to cover both new thinking in the field and also to balance the top down engineering approach found in many countries in the past. Additionally, wider dissemination of the knowledge, information and documents is also required, and should be made available to practitioners at all levels throughout the basin. As was pointed out in the consultants' proposal, these documents are aimed at guiding the senior professionals within the Nile Basin countries in their task of informing their own practitioners. Production of appropriate manuals and standards is the responsibility of National Governments who are well familiarised with their own national plans, programmes and target groups. It has already been acknowledged that this approach will significantly contribute to the broadening the use and knowledge of available systems.

During the preparation of this report it was very clear that understanding of the concept of *Best Practice* differs greatly throughout the Nile Basin, and amongst the groups consulted (Politicians; Decision Makers; Professional Practitioners; District and Field Level Technicians;). Whereas it is convenient to try and define best practice, the actual definition will vary from country to country relying upon their own assessment of the performance of the interventions. Currently, the formal sharing of data between and within Nile Basin countries is very limited, relying to a large extent upon papers presented at workshops or through the resources of regional or international organisations. Therefore, it is most important that experiences, information and data available within the Basin are made widely available to all practitioners. This will facilitate the learning process, and also take advantage of considerable past investments by donors in the preparation of manuals, guidelines and other tools, to facilitate the implementation process.

In many countries, war, turmoil and change of governments has meant that much of the already produced documentation is no longer available or institutionalised. During the first EWUAP Phase 2 workshop held in August 2008, it was apparent that there is an overarching need to ensure that reports, guidelines, manuals and other materials are stored electronically in a central location, so that they can be accessed and made available to any practitioner/professional wanting to consult more widely. With the increasing availability of internet access in all places within the Nile Basin countries,

[17] Information on these documents is available on the EWUAP web site.

[18] IPIA. Training Source Book No. 1. *Irrigation systems, their operation and maintenance. Muchangi P., I. Sijali, H. Wendot & P. Lempérière.* Training Source Book No. 2. *Socio-economics of irrigated agriculture. C. Philomena, A. S. Moeva, & P. Lempérière. March 2005.*

the obvious mechanism for ensuring data is accessible is through a suitable website. With the closure in 2009 of the EWUAP project, any developments that are made in this respect must be easily transferable to any subsequent government or institutional Web site.

1.5 Contents and structure of CBSSI Reports

During the course of the last year, the consultants have collected a wide range of useful reference material. This has been compiled in a format that could be easily transferred onto a suitable website for wider access[19]. The process has been started with more thought being given to performance and best practice, including the comparison of the concept in different parts of the Basin. It is essential that this momentum is maintained. Without a clear, articulated and widely understood vision for the future of efficient water use for agricultural production, a lot of interest stands to be lost particularly if practitioners cannot see how the completed work will lead into the follow up stage. Some very useful findings and data have been obtained during phases 1 & 2, but improvements in the understanding of efficient water use will depend to a large extent on how this is taken forward and used to the long-term benefit of agriculture in the Basin. It is essential that the follow-up be carefully charted at the higher level, using well experienced I&D practitioners so that this work does not become obsolete.

This final report on *Best Practices for Community Based (Small Scale) Irrigation* has been prepared after the initial workshop planned to present the findings, ideas and the way forward. It has been compiled from a review and analysis of the Rapid Baseline Assessment reports and reports on best practices, best practice sites and institutions completed by National Consultants. These have been supplemented by reports from various regional and international organizations, sector and basin wide study reports and other relevant documents, as well as the utilisation of the consultant's own knowledge and experiences of the sector. Throughout the work it has been emphasised that the results build upon data and information provided by individuals working within the sector in the Nile Basin. It therefore represents their understanding of the practices and issues involved, including their identification of better (best) practice sites. The development of the final report has been a prolonged process, due to the time taken to obtain data and information from all riparian countries. More often than not, the consultants were provided with data which came in varying forms and levels of detail. However, it is should be understood that this is a dynamic process, with findings which are flexible, and have the ability to adjust to the changing environment. It is envisioned that this report will provide a sound basis upon which each riparian country can build upon and improve, to meet their particular needs.

Part I of this report, contained in this document, provides an overview of the Best Practices in Community Based (Small Scale) Irrigation in the Nile Basin countries (Chapter 2). It discusses the features of Community Based (Small Scale) Irrigation best practice in the Nile basin (Chapter 3). In Chapter 4 and thereafter, the findings of best practices and the specific identified sites[20] in each country are discussed. This has built upon the research and discussions that were carried out in support of the EWUAP country studies on best practices. The details represent summary results for each country[21].

Part II (in a separate stand-alone document) provides appropriate guidelines for the implementation and application of most of the described and documented best practices. The guidelines aim to provide information on the processes to be followed, and that which need to be taken into consideration when planning and implementing Community Based (Small Scale) Irrigation projects. They have been written with the intention of providing senior professionals in each Nile Basin country with sufficient information, to enable them to produce or update practical guidelines and

[19] With these final versions of all reports, a CD Rom has been provided containing the key references referred to in the text to facilitate this process.
[20] Identified by the national Consultants and endorsed by each national committee.
[21] These differ from the national consultants reports as they have been presented here in a common format. It should be noted that national consultants reports were presented in different formats and not all countries provided similar levels of data and information. For copies of the original reports, the EWUAP web site should be consulted. http://ewuap.nilebasin.org/

manuals for their own target groups. Whereas some readers may find that there is not enough information for them, it is important to realise that the guidelines are aimed at people with the technical grounding and professional training in CBSSI, or an associated field, and with practical experience in the implementation of the same. As a result, it is up to these professionals to assist those with less experience, in the adaptation of these guidelines.

The focus has been on the improvement of small scale irrigation systems, both traditional and new, so that agricultural productivity can be improved, and the systems can be successfully operated and maintained for many years after construction or rehabilitation. Throughout the documents, there has been an effort to keep the guideline as a practical working document. It is envisioned that the extensive information provided will assist the practitioner in understanding the processes to be followed to achieve BP. This includes considerations to be made when planning, designing and implementing water harvesting projects.

Many links and references are provided to documents and manuals that can assist the reader with detailed design, construction and execution. These can assist the reader with all aspects of planning, design, estimation, construction and management, operation and maintenance (MOM). Each reader can take what they need from the documents to supplement their knowledge and information. Accompanying the reports are six CD ROMs that contain a wealth of published information and reports (see Table E.1 above).

Part III provides suggestions for both WH and CBSSI on how to improve upon the performance of both. WH and CBSSI are very closely connected with common constraints and requirements for further support. Both need to be treated in an integrated manner that extends from catchment protection down to use of available water resources. The proposals presented in the report will need to be developed into viable projects for implementation either by national governments or through basin wide projects implemented under the successor to EWUAP, the institutional support project (ISP)

2 OVERVIEW OF COMMUNITY BASED (SMALL SCALE) IRRIGATION IN THE NILE BASIN

2.1 The Setting for Community Based (Small Scale) Irrigation

The Nile Basin covers an approximate area of 3 million km^2 shared by 10 countries[22] with a currently estimated population of 300 million. Most of the population live in rural areas accounting for more than 80% of the population of Burundi, Ethiopia, Rwanda and Uganda. Despite being endowed with extraordinary natural resources and a rich cultural history, the Nile Basin inhabitants 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. Environmental degradation, high population growth and unstable political condition are overarching issues that pose significant threats for food security and the social welfare of the Nile inhabitants.

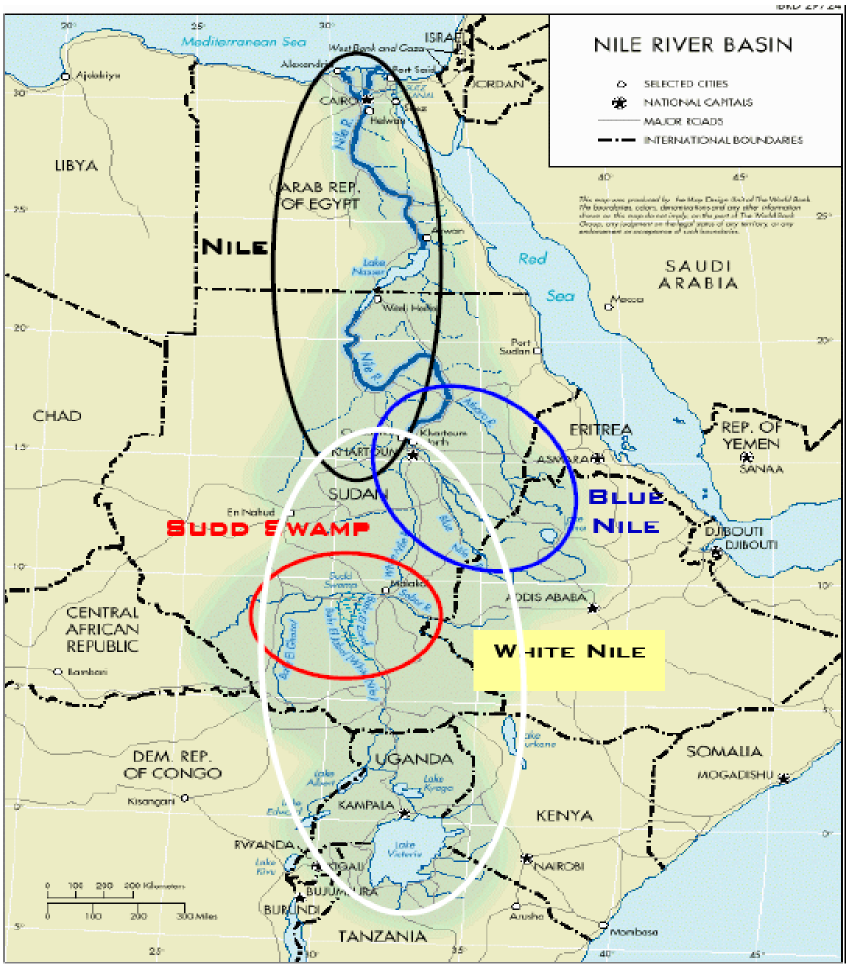


Figure 2.1: The Nile Basin

[22] All Nile basin countries except Eritrea are represented in the Nile Basin Initiative.

2.2 Climate and Water Resources

The main contributor to rainfall is the June to November precipitation that is often intense, causing rapid runoff. Population pressure on land within the Basin varies greatly with both Rwanda and Burundi having average densities of around 300 persons/km2. Rainfall, temperature and evaporation vary widely across the Basin with conditions for all year-round cultivation occurring in the North (Egypt and Sudan). Similarly, longer periods of cultivation occur 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 rain for rainfed cultivation, these statistics mask the true variability of rainfall that often occurs in intense storms separated by significant intervals of more than 20 to 30 days. In general terms, a third of the Northern part 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. However, variability in rainfall in recent years has meant that the short rains have been untimely, and much lower than expected. . This is particularly true in the southeast of the Basin. Except for Ethiopia and the Democratic Republic of Congo, 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 (see below).

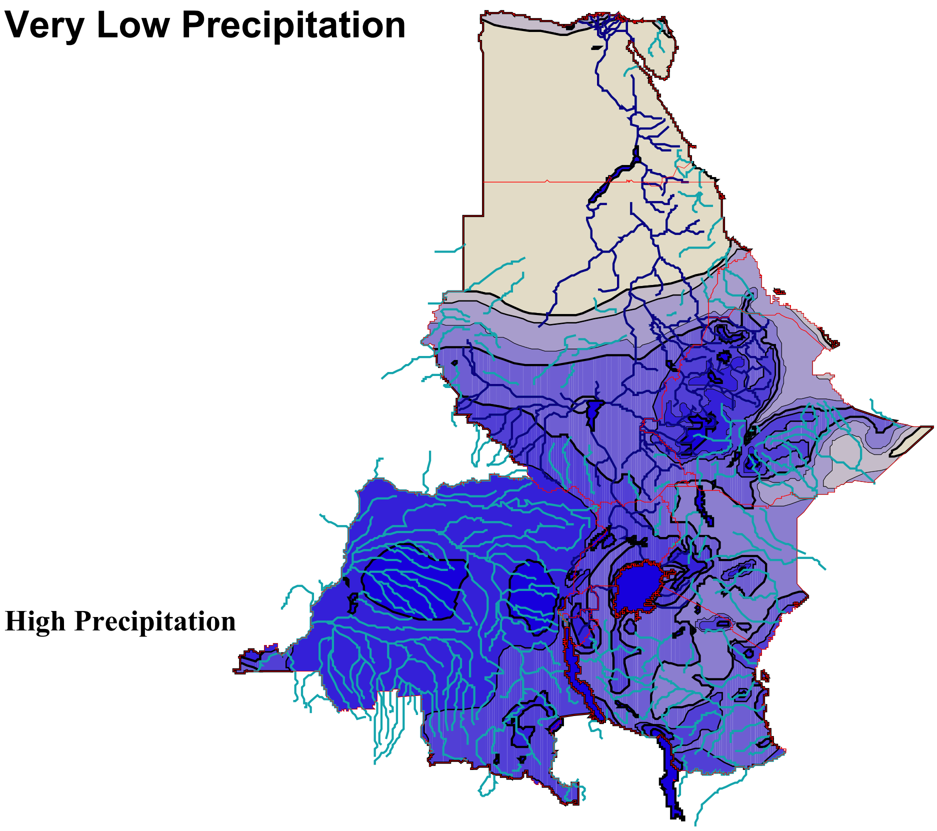


Figure 2.2 Rainfall distribution across the Nile Basin.
Source: FAO.

Studies reveal that meteorological data collection has rapidly declined in the last decades. A core network of meteorological stations is available in all riparian countries except DR Congo[23]. The dense rain gauge networks have been reduced, with detailed assessment of areal precipitation only possible using satellite images and remote sensing techniques. In addition, telemetry is hardly used in any of the Nile Basin countries. As a result, 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 2.1 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)	

2.3 Water Resources and Availability

Discharge at any given point along the main Nile River depends 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, but its flow varies considerably over its yearly cycle and is responsible for the large natural variations in flow. Similarly, the contribution from equatorial lakes is 14%, and this low amount is attributed to water loss by evaporation in the swamps (Sudd). Most of the river flow occurs during July to October.

Throughout the Nile Basin countries, there are wide variations in not only the hydrology and climatic characteristics, but also in the current level of water use for irrigation. Egypt, Sudan and Ethiopia are highly dependent upon water for agriculture (>90%), but only the first two countries use more than 5% of the annual water available in the Nile[24] (Table 2.2). Agriculture is by far the largest consumer 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, and this accounts for the lower dependence on irrigation with infrastructure less well developed[25]. In Rwanda,

[23] 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.
[24] Although data should be available from the FAO Nile Basin project, it has yet to be released. FAO Aquastat data have thus been used.
[25] 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.

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. Ethiopia has probably the largest cultivated area but has failed to realise the possible potential due to inadequate past investments, difficult terrain and poor access to markets. CBSSI is only developed to a small extent in Burundi, DRC, Rwanda and Uganda mainly due to topography, and adequate rainfall in most parts of the country. Kenya and Tanzania have better developed irrigation systems as compared to the other riparian countries. Moreover, with Tanzania has recognised the changing water availability and increased water demands, by adopting a river basin management approach to deal with existing and future conflicts.

Water quality and sediment transport are monitored sporadically in most Nile Basin countries. Under the Nile Basin Initiative (NBI) 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 water demands and potential. Although this data is not yet available, 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, and the t insufficient investment and expertise to develop these areas in the past.

Table 2.2 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.

Water measurement is an essential part of water sources management at catchment level, and also in the improvement in water use efficiency and productivity by users. Although in the past most countries had a comprehensive measuring network, insufficient funding in recent years has meant that regular collection and processing of data, especially from those stations in more remote locations has not taken place. Data for irrigation planning and development is therefore often incomplete, thus necessitating the correlation with other similar catchments with more complete data. Studies reveal that the use of older data does not reflect the recent impacts of climate change in the Basin.

Significant supplies of groundwater exist throughout the Nile Basin, but are only extensively utilised for agricultural production in Sudan and Egypt. Potential for expansion exists but rising energy costs will limit the use for agricultural production, except for high value crops, with most groundwater resources being used conjunctively with surface water. In addition, 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. Changing land use and decreasing 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 shown a significant change over the last

1-2 decades in base flows of surface streams. This has resulted in a lower availability of water for irrigation especially during the drier periods, and increased development of wetlands that has already impacted negatively on groundwater recharge. Adequate replenishment of groundwater is essential for maintaining the environment mainly through sustaining base flows in streams and rivers. Recharge of groundwater is derived from catchment management, natural drainage and wetlands, with contributions made from storage dams and other water retention structures

2.4 Agriculture

After meeting drinking water for human and livestock needs, agriculture is the next most important user of water in rural areas. Agriculture is the largest employer in all Nile Basin countries, either directly or indirectly. Egypt is the only exception, for although renown for its long history of agricultural development, the country has succeeded in diversification, and only 31% of the economically active population engage in agriculture[26], compared to most riparian countries which have more than 80% of the population engaged in agriculture. Kenya and Tanzania have slightly less people living and dependant on agriculture in the rural areas, reflecting the trend in diversification away from agriculture to industries and services. In Tanzania, Kenya, Uganda and Ethiopia, population coverage is spread widely over large rural areas, with often extremely undulating and inaccessible terrain. Understandably, this restricts government's efforts to reach all rural communities. Sudan, the largest country in the Nile basin[27], and Egypt have large land areas but most of the land is unsuitable for agriculture.

The major farming systems of the region broadly correspond with the main agro-ecological zones[28], although local factors – particularly market access – create potential for more intensive farming or for diversification within these zones (Table 2.3). 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 in these zones is 16% and 74% respectively. This shows that a large majority of people who depend on agriculture for their livelihoods, and tend to live in the higher potential sub humid and humid zones, thus creating high population pressures and increased small land holdings. Research shows that the current densities are unsustainable, and are likely to change with many people in different parts of the Nile Basin moving to the more marginal arid and semi arid areas where extensive poverty already exists. Community Based (Small Scale) Irrigation thus has a very important role to play in alleviating poverty and allowing greater productivity per unit of cultivated land.

Agricultural production is the most predominant economic activity in the Nile Basin with the large rainfed area being mainly used for subsistence agriculture for local consumption. In 2000, it was expected that production would gradually increase and approach self sufficiency[29], but with high population growth over the last decade, including the impact of variable rainfall and recurrent droughts, this has not been achieved. Although variations are experienced within the Nile Basin, productivity levels are still low with many of the Nile Basin countries dependent on importing significant proportions of food needs. Rising crop and fuel prices have highlighted this dependency which impacts mostly on the poor, who are less able to purchase food needs.

The primary staples in the Eastern and lower Nile comprise of wheat, millet and sorghum. In the Southern Nile, this changes to roots and tubers, although maize is also heavily consumed in some areas. Most parts of the Nile Basin rely upon low-input, low-yield subsistence farming and thus the scope for increased crop production lies in improvements and increases within the existing irrigated areas. As a result, higher outputs can be achieved for relatively low investments particularly as many of the infrastructural costs are already sunk.

[26] See Annexes to Agricultural Water in the Nile Basin – An Overview, Final Report, Ian McAllister Anderson, April 2008 for a detailed description of the situation in each country.
[27] The next largest country is DRC, however, only a small part of the country (23,000 km^2) drains into the Nile.
[28] 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
[29] Water and Agriculture in the Nile Basin. NBI Report to ICCON. Appelgren et al. FAO. 2000.

Table 2.3 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, rubber, 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

3 COMMUNITY BASED (SMALL SCALE) IRRIGATION BEST PRACTICE IN THE NILE BASIN

This section provides an overview of best practice in Community Based (Small Scale) Irrigation (CBSSI) in different regions of the Nile Basin. It initially examines the best practices available, and then in the following chapters leads onto an examination of country best practices. This draws on data available in the country studies on Best Practice prepared by national consultants[32]and confirmed though validation workshops in each country[30]. The available reports are summarised in Table 3.6. Interventions relating to Community Based (Small Scale) Irrigation are often well planned, but experience problems related to some or all of the constraints listed in Table 3.5 during implementation. Intended benefits are often not achieved in a timely manner and interventions are not fully owned and maintained by communities.

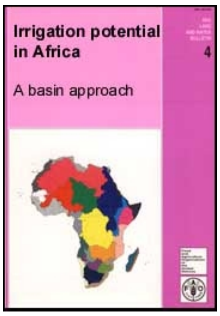
3.1 Extent of Development of Irrigated Agriculture in Nile Basin

The Nile is one of the nine largest basins in Africa, and contains 19% of the irrigation potential of the continent, which amounts 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 3.1). Irrigation for agriculture is the dominant user of water and is necessary to mitigate the seasonality/ 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.

Except for Uganda, where almost all of the country is contained within the Nile Basin, past investments for Upper riparian countries have been largely made 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 there has been an increasing need for irrigation 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.

Key Reference: FAO. 1997. **Irrigation potential in Africa**: A basin approach. FAO Land and Water Bulletin 4. Land and Water Development Division. FAO. Rome. http://www.fao.org/docrep/W4347E/W4347E00.htm

It concentrates mainly on a quantitative assessment based on physical criteria (land and water), but relies heavily on information collected from the countries. A river basin approach has been used to ensure consistency at river basin level. Where country information was unavailable or incomplete, potential was assessed on the basis of available information on land and water resources at regional and continental level. The FAO Geographic Information System (GIS) facilities were extensively used for this purpose. A physical approach to irrigation potential must be understood as setting the global limit for irrigation development. Future developments will be dictated by a whole set of factors, including political choices, investment capacity, technological improvement and environmental requirements.



[30] Information on Best Practice sites is not available for all Nile Basin Countries as some of the reports prepared for PMU/EWUAP did not respond to the terms of reference or complete the results in the format requested.

Estimates of the extent of irrigation development within the Nile Basin countries prepared by FAO[31] (Table 3.1) do not give a clear idea of the developments within the Nile Basin, as the data is not disaggregated. Only Egypt and Sudan have developed significant amounts of irrigation potential, of approximately (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 significant but 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 available data. 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.

Table 3.1 A Comparative Overview of Irrigation in the Nile Basin Countries[32]

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**
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

[31] Irrigation in Africa in Figures, Aquastat Survey, FAO, 2005.

[32] 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 4.3.

3.2 Performance from 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 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. Although this may have suited support for rainfed agriculture, 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.

In terms of total area and significance, traditional irrigation still outranks modern irrigation schemes in most regions of Ethiopia[33]. 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.

3.3 Development costs and Returns from Irrigation Developments

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 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 raising above US$ 20,000/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 CBSSI 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.

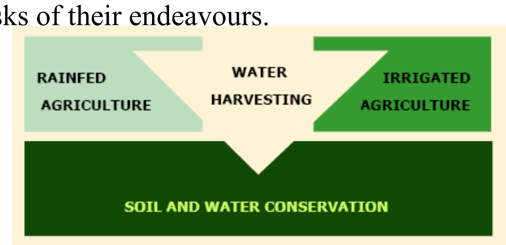
Recent support for irrigation has shown that with full beneficiary involvement, crop yields and returns can be significantly increased[34], provided that farmers are fully involved and irrigation investments are not treated as infrastructure investments. Where poorly performing developments exist, yields 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

[33] 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 54,800 ha versus 51,330 ha for modern schemes.
[34] For example under the RBMSIIP project in Tanzania.

food production and security[35] 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[36], investments and returns will be lower. However, 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.

3.4 Community Based (Small Scale) Irrigation

Since the 1990s, the effects of climate change has resulted in significant periods of marginal rainfall, at times when secure precipitation was expected, based on past experience. The undue reliance on the vagaries of rainfall has been shown to impact both the national economies and vulnerable smallholder farmers considerably. There has been an overall decline in assets and increasing food shortages for the rural poor, and those living below the poverty line. As a result, farmers can no longer rely on annual rainfall to provide good, reliable and regular crop production and are looking into both irrigation and water harvesting to reduce the risks of their endeavours.



Agricultural development has been hampered by many constraints varying from insufficient funds, limited demand or need, and prolonged periods of strife. Despite the widely acclaimed recognition of the role of irrigation in riparian countries, it is not the only solution. If all the irrigation potential were to be realised, studies reveal that only 10% of the currently cultivated land within the Nile Basin, would benefit from irrigation. It is essential therefore, that both irrigated and rainfed agriculture are supported in an integrated manner. This would raise production levels for small scale farmers who depend upon the cultivation of basic food crops for survival, as well as 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, enabling agricultural production to be practiced in areas that would otherwise fail 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, village, regional and national 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[37].

3.5 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

[35] 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.
[36] Such as with PIDP.
[37] As illustrated in the extension and research programmes of TARP and NAEP in Tanzania for example.

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), however, similar techniques are both beyond the financial capacity and management of small scale irrigation farmers. As a result, poor water management techniques are used by many farmers. There is an increasing 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.

3.5.1 Irrigation efficiencies

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

Data on conveyance and application efficiencies for irrigation systems within the Nile Basin is limited, with few countries taking measurements. When water delivered is compared with water used, low overall productivity is achieved. This is illustrated by data available from the adjacent Awash Basins in Ethiopia, where typical efficiencies from 30 to 55 % (average 35-40%) are achieved. These levels of efficiencies are realistic and show that considerable scope exists for the improvement of conveyance efficiencies and water productivity.

3.5.2 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, taking into account the 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[39]. 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 greater and water requirements are less and market linkages have been established.

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 CBSSI 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

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

[39] 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.

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.

Recent experience with small dam and diversion 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 either simplistic or too complicated for use by the less experienced staff charged with the implementation works. With increasing catchment degradation, sedimentation along with changes in river direction and local elevations at intakes and diversion sites is now of major concern. Inlet channels experience significant problems from sediment deposits and in some countries such as Sudan, river training and bank protection have become major areas for investment for irrigation systems. The situation is often more severe during the rainy seasons, as water needs decrease 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. 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 will address the concerns related to the identified cause and not the effect.

Water management on community irrigation schemes is one of the main areas for improvement. Where less control is exercised on water application, increased water logging 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.

Drainage plays an important part in reducing over irrigation and overcoming poor management within irrigated areas, as well as coping with excessive increased runoff derived 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. For instance in Kenya and Sudan, reports were made regarding deterioration in drainage systems in their large irrigation schemes like Gezira. Egypt has a large programme for overcoming salinity and water logging 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.

3.5.3 Community Management

In all riparian countries, small-scale irrigation developments comprise of government and community managed schemes, which have been developed by the farmers/communities, with limited to no government support. As a result of the heavy burden on government, there have been considerable efforts to dissociate from all schemes, especially SSI, with the number being included under CBSSI increasing. Many schemes planned for handover have deteriorated significantly from their original conditions and designs, and as part of the process of transfer, concerted efforts are need in the rehabilitation and upgrading of the systems, in order to make them more user friendly for community management. However, handover is not as simple as it may appear, and many groups have not received sufficient training or support for the process. Although there are now few SSI schemes still run by governments, the handover has in many cases been too rapid without adequate follow up and training. Hence their performance varies considerably across the Basin.

The situation on 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[40], but the condition of infrastructure is in most cases poorer than on the formal/modern irrigation systems. Water Users 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. 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, the result has led to unsustainable interventions and solutions beyond the capacity of farmers to operate and maintain.

3.6 Best Practice in Community Based (Small Scale) Irrigation

When examining an area the size of the Nile Basin which covers ten countries, it is important to have a reasonable understanding of what are considered as best practices, and to establish common criteria for identifying and profiling them. A *Best Practice* in Community Based (Small Scale) Irrigation is a good example of what can be achieved for wider dissemination that meets communities needs, is regarded by them as suitable, appropriate and manageable and which they are committed to and regard as their own[41]. As such, the CBSSI system can be used for benchmarking[42] other interventions/systems, as well as providing models for training and learning by potential users

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: (i) Technical, (ii) Economic, (iii) Social, (iv) Management, Operation and Maintenance (MOM), and (v) Institutional. Whereas all aspects of a particular site cannot be expected to be regarded as *Best Practice,* there should be sufficient impact so that overall the lessons and experiences of the site can provide examples/models to others. In the working sites[43] of each Nile Basin country, there will be elements from which others can learn and on which the particular site can build to improve the remaining aspects of the site. For example, the *Best Practice* of a particular site may encompass good organisation and management, but fail to meet the water needs of the community/farmers, or obtain poor prices and returns for crops produced. This may be due to external factors such as limited markets for produce, poor access to markets (poor infrastructure) or internal factors such as

[40] 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.

[41] The EWUAP workshop on best practices (Inception Workshop, Identification, Selection and Description of Best Practices, Best Practice Sites and Centres of Excellence in Water Harvesting, Community Based and Public/Private Managed Irrigation, Lenana Conference Centre, Nairobi, Kenya, 27 & 28 November 2007) defined ***Best Practice*** as "*One that gives optimum utilization of land and water resources for sustainable agricultural production and environmental management*."

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

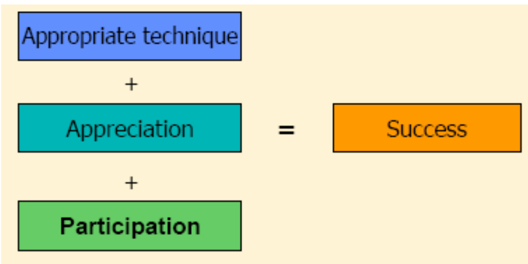
[43] Many research sites claim to be examples of *Best Practice*, but without more applied and proven on-working site experience within communities, these still remain theoretical and cannot be regarded as best practice until the most difficult aspect of obtaining community uptake and involvement has been completed.

inappropriate designs, poor adaptation to site conditions, poor construction, high costs requiring unrealistically high payments to meet O&M charges. The attributes that Community Based (Small Scale) Irrigation systems should exhibit are given in Table 3.2.

Table 3.2 Attributes of Best Practices for Community Based (Small Scale) Irrigation

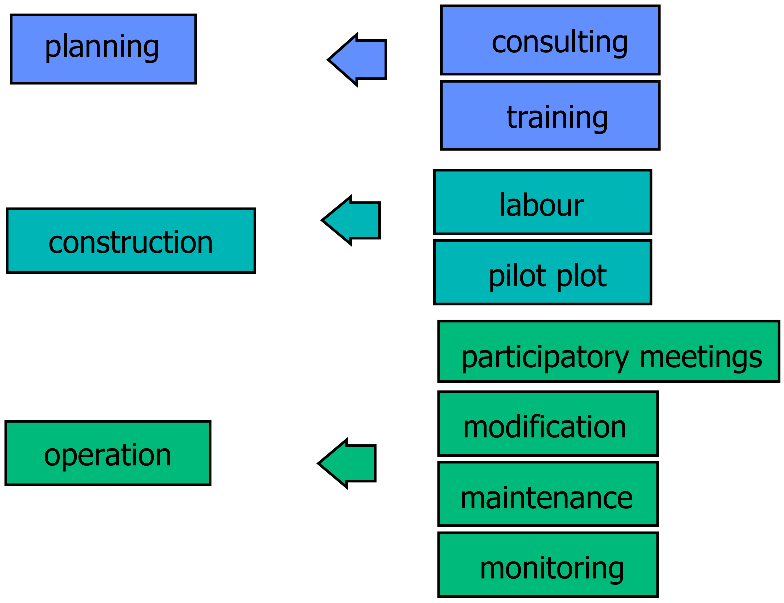
Community Based (Small Scale) Irrigation
Good example to be applicable to other areas
Has wider applications to other areas (and sites) either in similar environments (AEZ) or in general terms when concerning management/institutional aspects (=>Replicability)
Widespread community acceptance and support
Consideration of communities' interests living up/downstream of site.
Politically acceptable in a bid to influence funding.
Environmental friendly to ensure the conservation of the same.
Replicable to other areas with similar environment (AEZ)
Simple to operate and maintain with MOM costs within financial capacity of communities.
Easy to set up.
Technology easily adaptable to site conditions with local staff capable of adapting standard designs to field situations.
Should use local material as a priority.
Meets indentified needs of communities and seen as a viable solution by them.
Beneficiaries easily trained in technologies.
Technology has wider replicability/market potential to keep costs low.
Well adopted/owned by the local community
Owned, operated and maintained the community.
Good level of community participation in planning, design and operation.
Regarded as their own scheme with various community members given responsibility for different aspects.
Part/all of system managed/owned/leased by community.
Efficient use of water
High percentage of water demands met.
Water stored conveyed to users/user sites with minimum losses.
Water used for crop production applied efficiently to fields using water saving methods and technologies.
Water losses at abstraction/user sites minimised with health considerations featuring highly.
Good and easy to use abstraction points that avoids over use/ wastage and that has system for policing & providing equity & reliability).
Water productivity considered in agricultural applications (kg/m^3; US$/$m^3$).
Profitable
Proven successful results with respect to domestic, livestock and crop water needs.
Cost/Affordability – can be maintained through reasonable contributions from all members of the community.
Provided benefits to the local population through time saving, improved health, reduced losses of livestock, reduction in food insecurity.
Has wider applications through establishment of revolving funds or payback conditions that attract outside financial support.
Technology durable with minimum maintenance in first 2 years.
Technology supported through locally available skills (and spare parts if appropriate).
Technology uses local available raw materials where possible.
Cost-effectiveness (re benefits and number of beneficiaries).
Proven impacts on HH poverty reduction and family income.

The best practices that can be used are discussed in the following sections, but it must be noted that the use of good techniques does not guarantee best practice. Selection of appropriate improvements to or requirements for CBSSI schemes with the community, and the adaptation to the site conditions and local experience during implementation, are most important to ensure sustainable developments.



The best technologies are the ones that can be afforded and managed by the beneficiaries, and that utilise available local materials for installation, repairs, as well as 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).

Most importantly the whole process of planning, selection, construction and operation must be fully participatory.



Farmers must be made fully aware of the advantages and benefits of CBSSI. Similarly, farmers groups and village councils must be fully involved, with the benefiting communities able and willing to assist in the whole process and to provide inputs during planning, design, construction, management and maintenance. Local experience with CBSSI must be taken into account, and include many of the lessons learnt elsewhere taking account of many of the lessons learnt elsewhere. All community members (men, women, elders and young as well as the poorest) should participate in all aspects of CBSSI.

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. An assessment of information available on CBSSI schemes within the Nile Basin has shown that Best Practices depends heavily on beneficiary involvement, and the cohesiveness of Water Users Organisation (WUAs). If the system has been designed by the communities themselves with minimal 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.

Table 3.3 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 & secondary systems – Water users associations.

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

When assessing the level of success of an irrigation and drainage scheme, key descriptors (Table 3.3 above) provide a good overview of the aspects which should be taken into consideration. These factors have been prepared taking into account benchmarking of irrigation and drainage projects, to identify areas for improvement as well as comparison between different projects. 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. The studies on best practices carried out by the National Consultants in November and December 2007, showed that there is inadequate information and details on the existing small-scale and community irrigation within the Nile Basin countries. For instance, 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. Available information has shown the vulnerability of communities to the vagaries in the rainfall[44] 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. Crop yields vary

[44] 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%).

considerably with management practice, this includes: 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 and, with improved crop management and crop intensity, can be increased considerably.

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. 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 CBSSI 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.

3.7 Prioritization and Selection processes and Results

The National Consultants, who examined the best practices in the riparian, each prepared a system for ranking their projects using guidelines prepared by EWUAP. Despite attempts to ensure a certain basic level of data and information were collected, many failed to follow the approach requested. Levels and completeness of data and details thus differed considerably, and on some of the key issues such as WUAs and participation, only general comparisons were possible. What was clear was that guidelines, experience and understanding of the MOM issues were not extensive across the Nile Basin. The main considerations are presented in Table 3.4, and these can be used widely as they identify the issues that all planners and designers should be using. Community involvement and adaptation ranks high for all CBSSI systems. This has been derived from past experiences, whereby many schemes have failed or have been unsuccessful due to a lack of sufficient community involvement in the early stages of project preparation/rehabilitation, and subsequent O&M. The selection of the best practices and sites for each country was determined using the national consultant's own ranking system, with the results confirmed through field visits and discussions with those familiar with the projects. Similarly, National Project Coordinators and experienced professionals in both the public and private sector provided the necessary peer reviews and comments. However, although some sites did not fulfil all the criteria for best sites, they had outstanding attributes above other practices/sites in the country.

3.8 Constraints to Implementing Best Practice

A wide number of constraints affecting agriculture and agricultural water use in the Nile Basin countries have been identified, as well as 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. 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 3.5), and the way in which they are affecting Community Based (Small Scale) Irrigation.

Table 3.4 Ranking of CBSSI 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 Adapted 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 positive 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 3.5 Constraints to Community Based (Small Scale) Irrigation

General	Agriculture	Water Resources & Availability
Insufficient coordination of programmes and institutionalisation of experiences	Increase in cultivated area lagging behind rate of increase in population	Insufficient water to meet demands and Increasing levels of pollution
Increases of urbanization and growing population pressure	Poor yields, low productivity and low water use efficiency	Insufficient awareness of water productivity and the need to improve understanding and adoption of appropriate measures.
Declining land and water productivity	Poor adaptation of technical packages for production	
Declining landholding sizes and more family members dependent on irrigated plots	Limited access to (improved) seeds and inputs and Loss of crops to disease and pests.	Insufficient information on quality & extent of groundwater resources and declining quality.
Lack of good enabling environment (Policies; legislation; etc).	Decline in soil fertility and deterioration in physical properties	Greater emphasis needed on importance of River Basin Management approach.
Role of irrigation in the development of agriculture not well articulated and widely understood.	**Extension Services**	Need for a greater use of flow monitoring as well as early warning systems for floods and droughts.
Community Based (Small Scale) Irrigation	Inadequate extension services for CBSSI in agronomy & water management, technical aspects & strengthening of community groups	**Water Management and Productivity**
Inadequate involvement of communities at all stages of project development and system rehabilitation.	Lack of extension technical capacity and Insufficient Training and supporting incentives for extension staff, particularly in remoter rural areas.	Inadequate attention to Management, Operation and Maintenance at local level
Lack of priority list for support based on clearly defined ranking criteria.		Insufficient attention to the formation of Community Groups and WUAs and inadequate community participation
Lack of engagement of multi-disciplinary teams at planning and design to work with all beneficiaries and stakeholders.	Lack of information, knowledge and skills for communities and technical staff.	
	Lack of extension support for the establishment or strengthening of WUAs	Poor Water management and low conveyance and application efficiencies
Poor management and performance of public managed irrigation schemes	Need for the introduction of a Farmers Field School (FFS) approach in irrigated extension services	Inadequate farmer participation and Handing over of Systems to WUAs not well established or formalized in country and project documents.
Siltation & erosion of river offtakes & canals.	Need research system linkages to the farmer.	
Full range of technologies available not provided to users and Insufficient high profile of Productivity in all Nile Basin Countries leading to insufficient adoption and uptake of appropriate technologies	No effective grassroots/village-based, commercially oriented institutions	**Finance and Funding**
	Marketing	Relatively High Development costs.
		Limited availability of funding for CBSSI Rehabilitation and Improvements
	High marketing costs on agricultural produce in wider markets and restricted access to all but local markets.	
Lack of production of suitably detailed I&D design documents.		Potential for upscaling and improvement of Productivity not being addressed.
Processes and requirements for Planning, Design and Construction, Implementation of I&D not sufficiently well defined and supported.	Insufficient detailed support to Marketing of crops and establishment of market linkages.	Need and good potential for improvement of I&D not being addressed in a timely manner.
	Lack of information, knowledge and skills	In sufficient appropriate attention to the use of water charges/irrigation service fees.
Insufficient technical practical knowledge of detailed planning, design and construction of CBSSI.	Poor market facilities and high marketing margins on agricultural produce	
		Asset Management concept not widely used or understood.
	Limited availability of Market Information	
Limited availability of suitably detailed documents on CBSSI planning, design, construction and implementation for all staff.	Changing needs towards export markets	
	Poor access from irrigated areas for markets and provision of inputs.	

3.9 Improvements to Community Based (Small Scale) Irrigation

There is considerable scope for improving CBSSI schemes in each Nile Basin country through the greater involvement and development of WUAs. Diagnostic surveys have been completed under the APPIA project in Kenya[45] and developed into recommendations for improvement[46]. Guidelines and manuals for greater involvement of the communities have been established, and in Tanzania many of these have been field trialled and improved over the last 4 years[47]. These experiences should be used to develop guidelines and methodology for different types of intervention and for different target groups. What appears to be lacking is good implementation guidelines aimed at assisting professionals in each country to equip communities with full information on technologies types, and the conditions under which they will operate effectively. The skill in achieving success in Community Based (Small Scale) Irrigation structures is community involvement from the very start of the support process, so that any interventions address the key issues of the farmers, and the scheme remains the farmers at all stages. In addition, local conditions need to be evaluated prior to selecting the best practice for the area. Construction of Community Based (Small Scale) Irrigation can be easily done depending on the size, economic status of the community or individual and the intended use. However, there needs to be community demand and available markets for the produce.

3.10 Other Constraints to Community Based (Small Scale) Irrigation Development

3.10.1 Physical Constraints

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. The soil on degraded lands is typically impoverished or eroded, as there is less water available due to increased surface runoff or contamination. In addition 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 on irrigation schemes, and disruption of natural ground water recharging. Data on the measured extent of degraded land in the Nile Basin or elsewhere[48] 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.

Sedimentation problems are 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. 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 can degrade small wetlands and reduce the capacity of shallow lakes, some of which are used for irrigation.

[45] Financed by the French Ministry of Foreign affairs
[46] Improving the Performance of Irrigation in Africa (IPIA). June 2004.
[47] Through considerable and continued support from JICA.
[48] Nile Basin Initiative, May 2001. Transboundary Environmental Analysis. Nile Basin Initiative, Shared Vision Program.

3.10.2 Support services

Extension Services. 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 Community Based (Small Scale) Irrigation. However, extension support needs to be improved in order to cover the full range of crop and technical issues found in Community Based (Small Scale) Irrigation. The success of CBSSI relies on being able to offer a solution that meets the full needs, both perceived and actual, of the benefitting rural communities and that takes account of actual site conditions. The Farmers Field School (FFS) approach introduced by FAO has been introduced into most Nile Basin countries[49] and continues to be used in many areas. This approach could be extended to cover CBSSI however; financial support will be 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.

Marketing. Marketing throughout the Nile Basin is constrained by long distances to produce markets, impassable roads and lack of affordable transport. Much of the transport infrastructure is impenetrable in the rainy seasons and causes damage to the transported produce at other times. The issues related to marketing are complex and vary throughout the Basin. Some of the smaller Community Based (Small Scale) Irrigation schemes will cater for local markets, however most will target regional, national and sometimes export markets. The establishment of market linkages will therefore become an important part of this support. Extensive research suggests that the lack of these linkages is often the cause for projects not attaining the anticipated outputs.

Management, operation and maintenance (MOM). A lack of guidance in MOM at local level, either sub district or district level, has meant that farmers and beneficiaries have relied too much on government support for maintenance tasks. Many of these maintenance tasks can be handled by participation within the community at the early stage of the project cycle. When communities take over, they must be equipped to deal with not only routine O & M, but also capital expenditure through local revolving funds to upscale and to permit others in the community to take advantage of the systems.

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

Table 3.6 Details of Best Practice Documents for CBSSI Prepared by National Consultants

No.	Country	Best Pratice Report (MS Word)			Annexes (Excel)			Validation Workshop Proceedings			Remarks
		Title	Date	Size (KB)	Title	Date	Size (KB)	Title	Date	Size	
1	Burundi	Final Report (version corrigée).doc	22/04/2008	2,704	CMI and PPMI Inventory.xls	22/04/2008	29	Rapport atelier de validation	30/04/2008	2688	Not completed according to
					RDCI (CMI).xls	22/04/2008	163	Royal.doc			the requested format and
					SUCOMO (PMI).xls	30/04/2008	141				terms of
2	DRC	DRC Draft Best Practice Report (Fre	18/09/2008	313	Not provided			Not completed			reference/guidelines.
3	Egypt	BP-Egypt Final Report.doc	09/06/2008	38,538	Annex 1-List of Selected BP sites of CMI and	21/12/2007	40297	BP_Workshop-Egypt-.pdf	29/05/2008	815	This report has been
					Annex 2-List of Selected BP sites of WH.xls	18/05/2008	11238				completed well and
4	Ethiopia	Updated FINAL REPORT EWUAP best	22/06/2008	2,274	Chole_CMI.xls	01/06/2008	65	Ethiopia draft BP Workshop	01/05/2006	69	Final version of workshop
		practice 30 May 2008.doc			Godino_CMI.xls	01/06/2008	61	proceedings.doc			proceedings including
					Indris_CMI.xls	01/06/2008	66				attendees still awaited.
					Kobo_Alewuha_CMI.xls	01/06/2008	59				
					WH_Abreha_Atsbeha__Ethiopia.xls	01/06/2008	64				
					WH_Chekorti_Ethiopia.xls	01/06/2008	54				
					WH_Gergera_Ethiopia.xls	01/06/2008	57				
					WH_Mekuh__Ethiopia.xls	01/06/2008	63				
					WH_Migulat_Mekedo__Ethiopia.xls	01/06/2008	56				
5	Kenya	FINAL REPORT ON BEST	14/05/2008	15,978	MweaIrrigation(PMI).xls	19/06/2008	147	BPvalidationworkshopreport_1_k	17/04/2008	241	
		PRACTICES - KENYA (B).doc			BPsitePerkeraPMI.xls	18/07/2008	146	enya_final.doc			
					BPsiteLare(WH).xls	19/06/2008	1045				
					Kibirigwiirrigation(CMI).xls	19/06/2008	54				
6	Rwanda	Country report Rwanda.doc	07/07/2008	1,984	Appendix 1 LOCATION WH,IR SITES.pdf	07/07/2008	159	Resolutions_on_BP_Report_Pres	09/06/2008	34	
					Appendix 2 KANYONYOMBA.xls	07/07/2008	207	entation_rwanda.doc			
					Appendix 3 BUGARAMA.xls	07/07/2008	284				
					Appendix 4 Kisaro.xls	07/07/2008	1684				
					Appendix 5 and 6.doc	07/07/2008	64				
7	Sudan	Sudan_Draft_report_best_practices.pdf	18/09/2008	354	Not provided			Not completed			
8	Tanzania	Country Report Final Draft - June	18/06/2008	1,115	In Main Report						NPC still to provide
		2008.doc			Appendix 2 Details of best WH	23/05/2008	424				complete version of
					Appendix_3_Details_of_best CMI_Tanzania.xls	12/12/2008	290				workshop proceedings.
					Appendix 4_Ranking of best CMI_Tanzania.xls	18/06/2008	31				
					Appendix 5_Details of best PPMI_Tanzania.xls	22/05/2008	375				
					In Main Report						
					Appendix 7_Tanzania.doc	13/12/2007	940				
					Appendix 8- Ranking of irrigation best	03/01/2008	22				
					Map_of_AEZ_Tanzania.doc	26/11/2007	669				
9	Uganda	Uganda NB Final Report June 08.doc	13/06/2008	6,525	NBRWH BP Reporting-v2-edwardkanyarutokye.xls	19/03/2008	42	Uganda_Validation_Workshop_1	15/06/2008	53	
					NB RWH Ekiryotozi valley tank.xls	20/03/2008	46	5 June 08.doc			
					NB ranking bp tech.xls	21/03/2008	49				
					NB Comm Trr_BP Reporting Sembusi.xls	22/03/2008	42				
					NB_LS Irr Doho_BP Reporting.xls	23/03/2008	45				
					NB_BP RWH KyamuyimbaReporting.xls	24/03/2008	44				
					DRWH BOQs.xls	27/01/2007	71				
					NB Template for BP Reporting-v2-filled.xls	27/01/2007	66				

4 BURUNDI

4.1 Overview

Burundi covers an area of 27,834 km^2 of which 2,634 km^2 is covered by lakes. Forests cover an area of approximately 200,000 ha, but this is declining due to increasing population pressure. The country is predominated by a mountainous terrain, resulting in climate which is classified as tropical; hot and humid at low altitudes, and temperate and moist in the mountains. The river system in Burundi is divided into two major watersheds: the Nile and the Congo Basins. With an estimated total population of around eight million, average densities are 317 inhabitants per km^2 rising to 400 to 500 inhabitants per km^2 in the populated areas of Buyenzi, Kirimiro and Mumirwa. More than 90% of the population are involved in agriculture, providing 95% of the country's food supply, and contributing to 49% of the GDP (US$ 95 per capita per year. Burundi is currently ranked as one of the five poorest countries in the world.

In general, although the country's topography is characterised by hills or mountains, it also accommodates three significant plains, namely: Imbo, Buragane and Bugesera. . Annual average rainfall varies from 700 to 2,000 mm / year occurring in two rainy seasons: the first from February to May, which provides 60% of precipitation, and the second from September to December. Rain-fed agriculture is the primary agricultural practice carried out, with evidence of very little irrigated agriculture. Studies indicate that the agricultural sector is largely oriented towards subsistence farming, with the arable land under permanent crops occupying approximately 1,200,000 ha. A total number of 29 food crops are produced in the country, which account for 90% of the area under crops, whereas fish products (from natural lakes and rivers), oilseed and 30 industrial crops make up the remaining balance.

Figure 4.1 General Location Map of Burundi

Average farm size in the densely populated regions of Buyenzi, Kirimiro, and Central is approximately 0.5 ha, with the largest land holdings (2 - 5 ha) located in the plains regions of Imbo and Moso where population densities are lower. Cultivation in three seasons is possible, reducing the negative impact of the small farm sizes.

4.2 Agro-Ecological Zones (AEZ) of Burundi

Burundi is divided into eleven regions and five agro-ecological zones. The details of each are given in Table 4.1 and the location in Figure 4.1.

Table 4.1 Main Features of Agro-ecological zones

Natural regions		Agro-ecological zones	
1	Imbo	1	IMBO plain - along Lake Tanganyika; lowlands of 774 to 1,000 m elevation; warm tropical climate (23°C mean temperature); low rainfall (800-1,000 mm/an); 5-6 month dry season; occupies about 75 of country
2	Mumirwa	2	West of Congo - Nile divide (western escarpments) - mountainous area; elevations ranging from 1000 to 2000 m; annual rainfall ranges from 1100 to 1800 mm; temperatures varying from 23°C to 17°C as a function of altitude; occupies 10% of country
3	Mugamba	3	Congo - Nile Divide - altitude ranges from 2,000 to 2,670m; annual rainfall from 1,500 and 2,000 mm; equatorial mountain climate; mean annual temperatures of 12 to 16 ° C; 3 month dry season (June to August), almost daily rains in season and heavy in April and November; wettest part of country; contains natural forest; occupies 15% of country.
4	Bututsi		
5	Kirimiro	4	Central plateau - altitude between 1,500 and 2,000 m, average annual rainfall from 1150 - 1500 mm; tropical climate; 4 month dry season (June-September); averages temperatures from 16 to 18°C; covers about 44% of country.
6	Buyogoma		
7	Bweru		
8	Buyenzi		
9	Buragane	5	East and North Depressions - altitude from 1,320 to 1,500 m; mean annual temperatures around 20 ° C; annual rainfall 600 to 1,100 mm; average humidity 65 to 70%. 5-6 month dry season; prone to drought; covers 24% of country
10	Moso		
11	Bugesera		

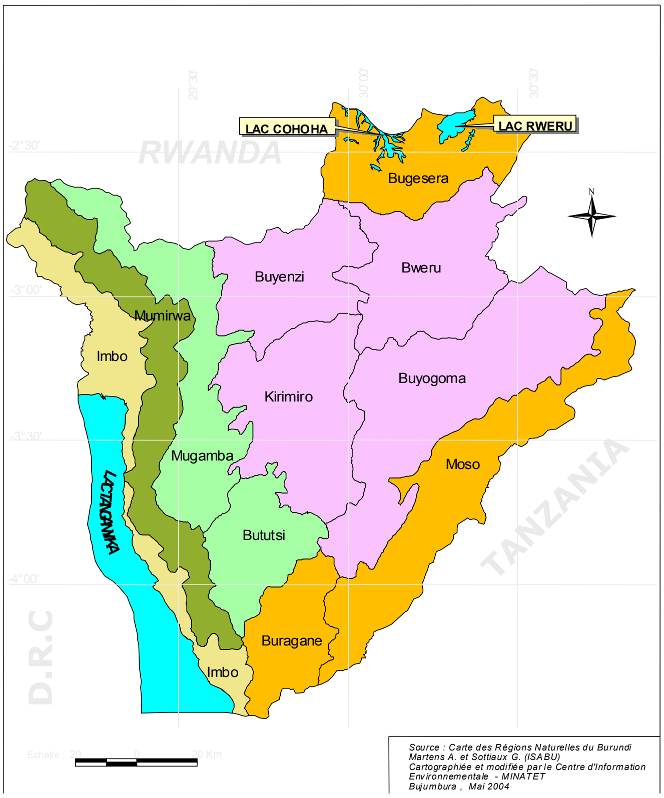


Figure 4.2 Regions and AEZ of Burundi

4.3 Community Based (Small Scale) Irrigation Sites

However, studies identified some examples of CBSSII, as well as larger privately operated systems. Currently, no prioritisation of the CBSSI has been made, and neither has an assessment of current practices been undertaken. The identified sites are located in AEZ 1, 2, 3, and 4, including the area with the greatest need for community based (small scale) irrigation. It is worthwhile to mention that despite the turmoil which has placed considerable pressure on the country's social fabric, farmers associations do exist. Understandably, more research is needed to identify sites, which have a wider application of water harvesting systems, and that can be utilised by the country to illustrate techniques and approaches to other potential users.

4.4 Identified Practices

In Burundi, over more than 99% of the irrigated lands are located in the plains of Imbo, Moso and Bugesera and in the swampy lands (Marais). Small scale irrigation (SSI) in the more hilly terrain (e.g. Rwira in Bururi province) represents less than 1% of the total irrigated area.

Table 4.2 Irrigated areas in Burundi

AEZ	Area (ha)		Irrigation		
	Total	Irrigable (ha)	Irrigated (ha)	Irrigated (% of total)	Irrigated (% of irrigable)
1	176,400	123,500	8,739	4.95	7,08
2	252,000	68,595	260	0.10	0,38
3	378,000	149,915	910	0.24	0,61
4	1,108,800	406,180	2,286	0.21	0,56
5	604,800	300,140	4,309	0.71	1,44
Total	**2,520,000**	**1,048,330**	**16,504**	**0.65**	**1,57**

Flood irrigation is widely practised with rice accounting for more than 80% of the crops grown. Other food crops (tomatoes, onions, corn, potatoes) and industrial crops (sugar cane, palm grove) are grow using furrow irrigation and a very small area using watering cans and trickle irrigation. Small Scale Irrigation carried out in the dry season uses small unlined channels with mainly irrigated vegetable crops. The irrigated area in most cases is less than five acres. CBSSI without technical assistance is common in the large valleys and swamps of the central region (central plateau or AEZ 4), as well as in the east and north depressions (AEZ 5). Farmers who have holdings in the same valley or the same marsh organize themselves to ensure equitable sharing of water with local administrations playing a lead role. Farm size ranges from 10 to 50 acres depending on the region. A complete list of these farms managed without any technical assistance could not be provided. CBSSI with technical assistance are modern farms where irrigation is overseen by public technical services under government/donor funding. The beneficiaries are grouped into farmers' associations whose average size is 10 households, with the same range of farm sizes as the non-assisted schemes. Plots are assigned by the administration to farmers under rental agreements and those households that are unable to meet these agreements resell to others.

4.5 Potential for Community Based (Small Scale) Irrigation

Burundi has only realised part of its estimated potential irrigated area of 215,000 ha. In the past, irrigated agriculture was not a priority and this, coupled with the instability in the country over the last 15 years, and has meant that further investments have not been forthcoming. With the growing population, there is a greater need for a more systematic development of potential including, and perhaps most importantly, the improvement in the productivity of existing schemes. There are untapped water resources in many areas and water shortage exists in all parts of the country at certain times of the year. Furthermore, the undulating terrain means that any proposals for expansion of irrigation have to be carefully adapted to site with careful planning in the absence of reliable streamflow and rainfall data. Drainage forms an important part of any developments, and care must be taken to ensure that environmental damage and degradation is avoided. Past strife in communities has meant that cooperation as groups for CBSSI projects require considerable efforts.

Limited basic information on identified CBSSI schemes is available or institutionalised, and experience within the country on how to plan, improve and manage the systems has been affected by the periods of strife. A number of schemes lack basic infrastructure and this limits the water use efficiency. Careful planning and improvement of these schemes with the beneficiaries could produce good increases in crop production and yields. More coordination of water use in the river basins is needed, and problems have been reported in Bubanza province between formal and informal farmers, outside the perimeters of formally irrigated areas.

4.6 Best Practice Sites

CBSSI schemes in Burundi were listed, but no details of Best Practice CBSSI sites were provided. A ranking process for indentifying best practices was made and results provided in the following tables. However, these schemes involve irrigation perimeters that are more than 1,000 ha except for Nyabiho. Each scheme was provided large scale irrigation (Regional Development Corporation of Imbo - RDCI) and public managed irrigation (SUCOMO) sites. Although there are smaller CBSSI schemes in most districts, information on these were not provided.

Table 4.3 Multi-criteria assessment of best sites

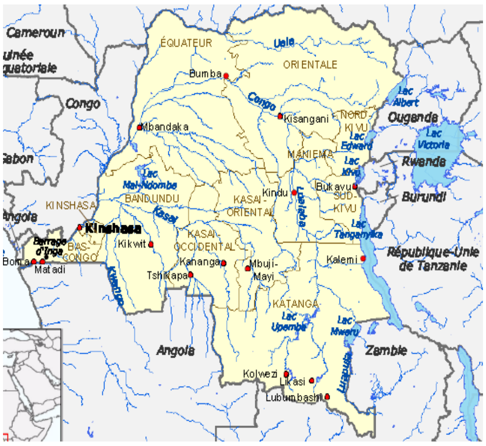
Sites	***Criteria***									
	Area of the irrigable zone	*Availability of water*	*Socioeconomic importance of the irrigated crops*	*Population involvement*	*Output (yield)*	*Marketing and marketing issues*	*Diversity of the crops*	*Accessibility*	***Total points***	***Rank***
	/10	***/10***	***/8***	***/8***	***/7***	***/7***	***/6***	***/6***		
RDCI	*10,0*	*8*	*8*	*8*	*7*	*7*	*6*	*6*	*60,0*	***1***
MPARAMBO	*3,9*	*9*	*8*	*8*	*6*	*6*	*6*	*4*	*50,9*	*2*
RUKOZIRI	*1,5*	*9*	*8*	*4*	*5*	*5*	*6*	*4*	*42,5*	*6*
RUMONGE	*1,9*	*8*	*6*	*6*	*7*	*6*	*4*	*4*	*42,9*	*5*
NYABIHO	*0,4*	*10*	*8*	*8*	*6*	*5*	*4*	*5*	*46,4*	*4*
MURAMBI	*0,5*	*10*	*8*	*8*	*6*	*6*	*4*	*6*	*48,5*	*3*

5 DEMOCRATIC REPUBLIC OF CONGO

5.1 Overview

Straddled by the equator and situated in Central Africa, lies the Democratic Republic of Congo which is the third largest country in Africa, covering an area of 2,344,860 Km^2. The country shares its border with African 9 countries most of which are within the Nile Basin. The only part East of DRC which is situated within the riparian is relatively small. Studies reveal that the total area under cultivation in the country was reported as 7.8 million ha in 2002, with 1.1 million ha consisting of permanent crops. Further studies reveal that in 2001, 80% of the country's population were living below the poverty line, and only 4% of the active population were employed. The availability of water underpins the social and economic fabric of the society in the country, which is characterized broadly as underdeveloped, with widespread poverty. In 2000, only 29% of the population in rural areas had access to clean water compared to 83% in urban areas. Evidently, water in the Democratic Republic of Congo is a vulnerable resource, and its vulnerability stems from several factors, some of which have already been mentioned above. Over the years, war and insecurity has plagued the country, thus restricting development as well as the effective collection of data on Community Based (Small Scale) irrigation. .

5.2 Agro-Ecological Zones (AEZ) of DRC



The country is divided into 5 main agro-ecological zones:
- Alluvial low valley in the centre of the country - altitude from 300 to 500 m; covers one third of country; vegetation is equatorial forest and swamps; low population densities.
- Savannah Plateau bordering Alluvial valley in North and South - 700-1200 m altitude; more densely populated.
- Volcanic ridges of high altitude in East and North-East - divides the Congo and Nile basins; 1,500 to 5,000m altitude; high population density.
- Litoral belt - extends from Ocean to Mont de Crystal.
- Katanga.

The climate is classified as equatorial; hot and humid in the centre, and progressively tropical towards the South and North. Rainfall is variable, but generally sufficient for two seasons of crop production (800 to 1800 mm/an), with the main rainy season lasting for about 8 months.

Table 5.1 Agro-climatic Zones of DRC

Agro-climatic Zones	Province	Annual Rainfall (mm)	Length of Seasons (months)		Vegetation
			Wet	Dry	
Equatorial	Equateur	1800 - 2000	>11	<1	Equatorial Forest
	Nord Bandundu	1500- 2000	>11	<1	
	Nord Maniema	1800- 2300	>11	<1	
	Sud Prov Orientale	1700- 2000	>11	<1	
Humid Tropical	Kasaï Or. & Occ.	1500	8-10	2-4	Savannah and Dry Forest
	Sud Maniema	1300	8-9	3-4	
	Nord Prov Orientale	1400-1600	9-10	2-3	
	Sud Bandundu	1100-1500	8-9	3-4	
	Kinshasa	1200 - 1500	7-8	4-5	
	Bas-Congo	1200 - 1500	7-8	4-5	
	Katanga	1200 - 1500	6-9	3-6	
	Ouest Kivu	1200-1400	9	3	Savannah and Forest
Mountain Zones	Est prov Orientale	1400	8-9	3-4	Savannah and Dry Forest
	Nord Est Katanga	1200	6-7	5-6	Savannah and Mountain Forest
	Est Kivu	1200-1900	9	3	

5.3 Community Based (Small Scale) Irrigation Sites

Poor access within the region due to damaged infrastructure and insecurity has prevented a complete inventory of CBSSI schemes. The national consultant has prepared some data on the sites that exist, but this is not completed and has been hampered by poor communication and the lack of institutionalisation of data and information. Although examples of CBSSI schemes have been provided, they have very limited details. For example, no AEZ Map is available, with the location of the identified sites. As a result, more work will have to be carried out to identify sites in the Nile Basin and elsewhere in DRC that have wider a application, and which can be utilised by the country to illustrate techniques to other potential users.

5.4 Identified Practices

Community Based (Small Scale) Irrigation is used in the drier zones of the country for supplementary irrigation and for crop production in the dry season following the rains. River diversion, which is mainly locally, constructed using informal structures, as well as pumping from rivers and small storage dams are used for CBSSI. Further information is not provided.

5.5 Potential for Community Based (Small Scale) Irrigation

Potential for the improvement of traditional Community Based (Small Scale) Irrigation has been identified, to overcome the impacts of population pressure especially in the Nile Basin catchment. Studies reveal that there is a lot of population movement from the neighbouring countries, and within the Eastern Congo. The increasing occurrence of droughts, coupled with the aforementioned population pressure, has increased the need for improved strategies for the development of new schemes, as well as the improvement of existing SSI. Nevertheless, few manuals exist to assist those involved with irrigation developments and experience within the country on how to plan, improve and manage the systems which have been affected by the periods of strife.

5.6 Best Practice Sites

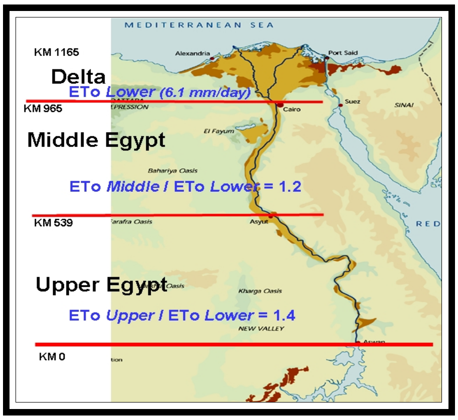
Six sites of best practice in Community Based (Small Scale) Irrigation were identified in order of merit. Although a system for prioritising them was developed, no further details were provided.

(a) Lemba imbu
(b) Nzundu
(c) Kimbanseke
(d) Lombe
(e) Ngandu
(f) Langa langa

6 EGYPT

6.1 Overview

Egypt lies in the north-eastern corner of the African continent, and has a total area of about 1 million km². It is bordered on the north by the Mediterranean Sea, on the east by Palestine, Israel and the Red Sea, on the south by Sudan and on the west by Libya. The country is divided into two unequal, extremely arid regions by the landscape's dominant feature, the northward-flowing Nile River. Cultivated land area is, estimated at 3.5 million ha (4% of the total land area), whereby 88% is covered with annual crops and 12% is dedicated to permanent crops (12%). Agriculture is an important part of the Egyptian economy employing 38% of the country's labour force, and representing 17% of Egypt's GDP. As on of the competing demands for water from the major sectors of the region's economy, agriculture places 80% of the total demand for water. The greatest challenge faced by the Egyptian government is the management of the ever-growing demand on the water in the country to ensure sustainable growth and poverty alleviation. Hence, it emphasizes the need to increase water use efficiency, and develop other sources to meet the competing demands for water from all sectors.



Annual rainfall distribution patterns vary from zero in the desert to 200 mm in the northern coastal region. In many districts, rain may fall in large quantities only once in two to three years. During summer, temperatures are extremely high (38°C to 43°C) with extremes of 49°C in the southern and western deserts. The Mediterranean coast has cooler conditions with a maximum of 32°C.

With highly productive soils, good climatic conditions, a perennial source of irrigation water and supportive irrigation and drainage services, average crop yields (rice; corn; wheat;) in Egypt are relatively high compared to the world standards, with 9.4, 8.1 and 6.5 t/ha being achieved respectively.

Figure 6.1 General Location Map - Egypt

Productivity (kg/unit of water) is also relatively high especially for crops such as rice.

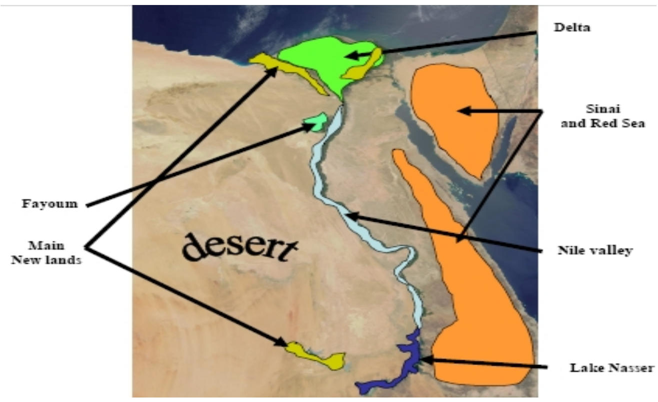


Figure 6.2 Agro-ecological Zones in Egypt

6.2 Agro-Ecological Zones (AEZ) of Egypt

Egypt is divided into five main Agro-ecological Zones (Figure 6.2).

(a) North Coastal Areas
(b) North Coastal Areas of Sinai
(c) Nile Valley and the Reclaimed Desert Fringes
(d) Inland Sinai and the Eastern Desert
(e) Western Desert, Oases and Southern Remote Areas

Table 6.1 Characteristics of Agro-ecological Zones in Egypt

Agro-Ecological Zones		Description
1	North Coastal Areas -Northwest Coast (NWC)	Forms a belt about of 20 km that extends for about 500 km from Amria to El Salloum near the borders with Libya. *Main Climatic Features*: Characterized by dry Mediterranean climate; average temp from 18.1 C° to 8.1 C° in winter and 29.2 C° to 20 C° in summer. Rainfall varies from 105 mm/an at El Salloum to 200 mm/an at Alexandria; most rainfall (>70%) occurs in winter months from December to January. Significant variation occurs attributed mainly to coastal orientation. Average mean rainfall decreases sharply from 150 mm near the coast to 50 mm at 20-70 km inland. NWC has highest average wind speed in Egypt reaching 18.5 km/hr in winter. *Soil and Water Resources*. Soil types and properties are highly influenced by geomorphic and pedogenic factors with the main soil units comprising of coastal oolitic sand dunes, soils of the lagoon depressions, consolidated dunes, deep sand and clay loam soils, moderate to limited depths of sandy to clay loam, wind blown formations and soils of the alluvial fans and outwash plains over the plateau. *Water resources* are mainly rainfall as groundwater resources are limited and usually of low quality (saline).
	North Coastal Areas of Sinai	The northern strip up to about 5 km from the coast has a very gentle S-N slope reaching about 20m ASL, which increases inland to about 90m ASL. The zone is characterized by the Tina Plain in the east, and is formed from Nile alluvial deposits in the lowest lying areas of Sinai. In the middle is the Bardaeweel lagoon (Shallow Lake) and from this, desert plains with large areas of sand dune belts and sand sheets extend southwards. The eastern part, having some of the highest average rainfall in Egypt (304 mm/an in Rafah in Sinai), is dissected by the largest Wadi in Sinai, Wadi Al Arish, which emerges f elevated gravelly plains and terraces in the south. North Sinai is characterized by a dry Mediterranean climate with relatively wet, cool winters and dry hot summers. Air temperatures are similar to NWC but with large diurnal variations. Annual wind speed is 14 km/hr in a north-west to north direction. Annual rainfall along the Mediterranean coast is 120mm/an ranging from 32mm/an in the uplands to 40 mm/an in the south of which 27mm is estimated to occur in 1-3 single storms. Rainfall in Sinai occurs during winter and spring. *Soil and Water Resources*. The desert soils of northern Sinai comprise Aeolian, alluvial and soil formed in situ. The latter is found in the plateau region of Wadi Al-Arish on either calcareous or volcanic parent material. The majority of alluvial soils constitute the present Wadi beds. The dune area is dominated by soils with almost no signs of soil forming processes and saline soils are found exclusively in the coastal zone. Haplic calciosols dominate the desert region in the gravel plains. The soils of the Tina plain in the west are heavily textured with high salinity content. *Water resources* Runoff occurs when storm rainfall exceeds 10 mm and in Sinai about 60% is lost to evapotranspiration. Groundwater occurs as (i) shallow groundwater - mainly within weathered layer of igneous and metamorphic rocks, quaternary rock, recent deposits such as Wadi fill or sediments and sand dunes and (ii) deep groundwater in semi-confined aquifers of per-Quaternary formation. Groundwater resources in the North Coastal area are limited and of low quality. The Al Salam Canal provides a third water resource and will convey mixed Nile and agricultural drainage water across the Suez Canal to reclaim 400,000 feddans in Northern Sinai.
2	Nile Valley and Reclaimed Desert Fringes	This agro- ecological zone represents the greater majority of cultivated lands of the Nile Valley, as well as, most of the reclaimed desert lands , mainly, on the western and eastern fringes of the Delta in addition to relatively limited areas at on fringes of the Valley in Upper Egypt; (Total areas over 7.5 million feddans). The Nile Valley system is one of the most ancient agricultural systems in the world. It represents the most fertile lands in Egypt and probably in the whole region. It is also the most densely populated area in the Middle East region. Agricultural products are highly diversified and intensive cropping system is practiced all year around. Despite the high significance of this sub-zone to food security, trade balance and economics, yet it has been the subject of several desertification factors and processes through the last few decades. Some of these factors and processes have been dealt with through technical and legislative measures which resulted in the significant decline of adverse impacts. *Geomorphology* The Nile Valley system extends from the Mediterranean shores of the Nile Delta to the North till Aswan in the south over an area extending from 22 - 32 latitude North under arid and hyper-arid conditions. Soil and Water Resources. The most pronounced feature of this agro-ecological zone is the Nile River which provides Egypt with 55.5 billion m3/year, with its magnificent High Dam providing perennial storage of excess Nile water, and Lake Nasser Nabia representing the largest man-made fresh water lake extending from about 500 Km south of Aswan beyond the Sudanese. The old Nile water conveyance system is still functioning, with additional major canals conveying fresh Nile water to the newly reclaimed desert soils in the fringes of the Valley, which are of relatively higher elevations. Sizable amounts of the agricultural drainage water of the old Valley are recycled in the conveyance system and mixed with the fresh Nile water to be used for horizontal expansion of cultivated areas. Groundwater (mostly recharged by the Nile water) is of relatively limited use in the Valley but is especially used in the desert fringes. Soils varied including the fertile deep alluvial soils of the old Nile Valley, soils of the river terraces at different relief's which are deep soils with gravelly and reddish sub-soils, in addition to the soils of the fringes including desert calcareous soils of varied textures and non- calcareous soils characterized with low soil fertility and inferior soil physical, chemical and biological properties.
3	Inland Sinai and Eastern Desert	It extends to north of the southern region, from which it is separated by huge excavation stretches in a N- SE trend as far as about 60 Km. This excavation which averages 10 Km width is opened from northwest, and is influenced by several drainage systems. These systems include Gulf of Suez system at the western and south western sides. Gulf of Aqaba system at the eastern and south eastern fringes. Perennial channel over flow takes place at several wadis dissecting the western and south western fringes of El Tieh table land. It occupies the central portion of El Tieh table land. To the west, it is limited by the upstream portion of W- Al Arish and its

		tributaries. This excavation stretches in a NW-SE direction for about 40 Km attaining about 15 Km width at bir El Malha area. Due to this excavation both Egma and El Tieh table lands are completely separated. The surface of these table lands are intensively dissected with drainage lines, flow towards north, and joining together into W. Al Arish. *The eastern desert is comprised of the following landforms*: (i) The high Rocky Mountains: Generally, the surface of the Eastern desert is very rugged and rises in some places to more than 2000 m ASL especially in the southern areas. (ii) The desert floor: it is covered with countless sounded highly-polished pebbles of brown flint or white quartz, materials brought down by ancient streams and spread out near the former shore-line. (iii) The drainage channels: They are intensely dissected by valleys and ravines and all their drainage are external. Most of the drainage lines run along major fault lines, and it is noticeable that while the eastward drainage lines runs to the Red Sea by numerous independent wadis, the westward drainage lines run to the Nile Valley . Coastal mountains from the water divide. *The plains Soils*. They represent the plain distributed along the whole area of Sinai; El Gifgafa, El Qaa and the plain located east of Suez Canal. They have a fine to moderate, texture, moderately saline and have agriculture utilization potential. The soils of Eastern Desert differ widely according to their contribution to the landforms. The soils are outlined in the following: *Water Resources*. Despite the very low rainfall over this zone yet the geomorphic factors combine with the intensity of infrequent rain showers to form flash floods which have definite adverse environmental impacts on infrastructure, soil- erosion and installations before being lost to the adjacent marine areas.
4	Western Desert, Oases and Southern Remote Areas	The available land resources in this zone are of weak characteristics and have a low resilience, with wide spread physical, biological and chemical limitations. Most of these resources are located in a closed fragile ecosystem which is isolated from the Nile Valley System. Management practices and utilization of those resources for agriculture and desert development should maintain these ecosystems free from invading pests and non desirable weeds and plant species, through the application of proper and integrated conservation practices. Conservation of the indigenous flora and fauna, including that of the preservation of the valuable genetic resources and species adapted to the harsh environment and hyper-aridity of this zone represent an important mean of combating desertification. Rational use and reuse of water resources is imperative, due to the enclosure of the ecosystem and the need to deal with excess drainage water in non-conventional ways, other than the traditional systems of the old Nile Valley. This would be of paramount importance, in order to prevent the presently prevailing conditions of water logging and salinization of soil and water resources. *Geomorphology.* The Western Desert which extends from the southern boarders towards the Northwest Coastal areas in the North, is a massive plateau with a general slope towards the north , starting from an elevation of about 1000 m asl to the extensive Qattarah depression which is 134 m below sea level. The western plateau is distinguished with uniform flat surface 40% of which is covered with sand dunes and extensive areas of sand sheets (The sand sea). Several depressions of varied areas are scattered in the western desert including the famous oases of Siwa in the north, Baharia and Frafra in the central section, Dakhla and Kharga in the south. These oases that are distinguished with artesian wells of large discharge of fresh water are mainly closed and fragile ecosystems where population is concentrated. *Climate.* This ecological zone is characterized by hyper-arid climatic conditions with rare rainfall and extreme temperatures. The winds over the western desert in the north western or northern direction extend from the Mediterranean over the western desert with reduced speed. These winds are the major factors of erosion and deposition processes in the western desert. A clear evidence of these processes is the formation of the great sand sea by the eroded sediments of the Qattarah depression, which is located in the north. *Soil Resources.* The soils have been classified as weakly developed Red Desert soils which have higher chrome than typical Red Desert soils and they have a very thin or no A-horizon. The formations of these soils are derived from a number of parent materials, indicating that the hot dry climate was the main soil forming factor that is responsible for the characterising these soils as Red Desert soils. The soils are formed of sand and are calcareous in nature. *Water resources.* Water resources are mainly that of the huge Nubian sandstone aquifer that extends with varied thickness under the majority of the area of the Western Desert. This major water resource is of excellent quality in most areas. The renew-ability of such a resource received many queries, with the majority of conclusions confirming a non-renewable or very slowly renewable water resource. However, in view of huge water resources available in this aquifer a macro developmental plan of the East Owenate area is currently being implemented. *Socio-Economic Constraints.* The present population and communities are scattered, and a majority have a low educational background. Although skills and handcrafts are available, the much needed technological skills which are required to address the needs of developmental activities are rare. There are is an urgent need to create incentives which will assist in reversing rural-urban migration trends including the attraction to the newly developed areas in the Western Desert in search of employment

6.3 Community Based (Small Scale) Irrigation Sites

Community based irrigation in Egypt dates as far back as the original traditional irrigation system in the old lands of the Nile Valley, in the times of the Pharaohs. It differs from the other Nile Basin countries, except Sudan, as the systems are contained in large tracts of land managed by community farmers, and official government organisations on a larger scale. The systems used combines gravity and water lifting systems, with the main canal system (first level) deriving water from head regulators, located upstream of Nile River cross regulators. Water is delivered to branch canals (second level) where flow is non-continuous to the third level distributaries. These receive water according to a rotation schedule, and water is pumped to irrigate the fields using 0.5-1.5 m of lift. Under the new improved system, the level of tertiary canals (mesqa) is raised above-ground level or set under pressure to improve distribution with rotational systems along branch canals being replaced by continuous flow.

A key feature of the Egyptian irrigation system is that the canals deliver water about 0.5-1.0 m below ground level, requiring farmers to lift the water onto their land. Lifting takes place at the head of the ditches (Marwas), either from the sub-branches (Mesqas) or, in many cases, directly from the branch canals themselves, many of which are illegal. In the past, lifting was carried out by mainly animal-driven water wheels (Sakias) (Figure 6.3) which were licensed by the irrigation districts. The sakia was a fixed installation whose sump was connected to the canal or mesqa by an intake pipe of specified diameter. The farmers' capacity to abstract water from the delivery system was thus restricted in terms of both number and location of lifting points and discharge. The need for several farmers to share the sakia combined with its limited discharge and the restrictions of the rotation system, meant that farmers were constrained in terms of when and for how long they could irrigate. Over the last 20 or 30 years, sakias have been progressively replaced by mobile diesel-driven pumps. Unlike the sakias, which were almost always collectively owned by the members of the sakia ring, most pumps are privately owned by individual farmers. However, a significant number of farmers do not own pumps, and instead have to rent them from others.

Figure 6.3 Typical Traditional Water wheel (Sakia)

6.4 Identified Practices

Figure 6.4 Marwa before and after lining

Surface irrigation predominates in Egypt, especially in the communally irrigated lands. Basin and furrow irrigation are widely used depending on the crops grown (Basin: rice, wheat, Berseem (clover), feed maize; Furrow: cotton, sugar beet, maize, vegetables). BP activities in old land have included on-farm irrigation management programmes, aimed at promoting measures to improve farmers' irrigation practices and water use efficiency, including land levelling, selective soil amendments and planting techniques. It has been estimated that newly developed short duration rice varieties, coupled with water management changes, reduce applied water by about 2,000 m^3, thus decreasing consumptive use per-feddan by about 1,000 m^3. This benefit depends upon the cropping pattern, and with early planting of the winter crop (principally clover) savings are reduced. Rice has become a very attractive crop to farmers, particularly those with short duration that permit early clover establishment, and the spread of this crop has utilised all of the estimated savings.

Figure 6.5 Improved Furrows

On farm improvements that have been introduced include lining of Marwas (ditches) (Figure 6.4), use of larger basins, furrow lengths and wider furrows (Figure 6.5). Flexible hoses are also used together with buried piped Marwa.

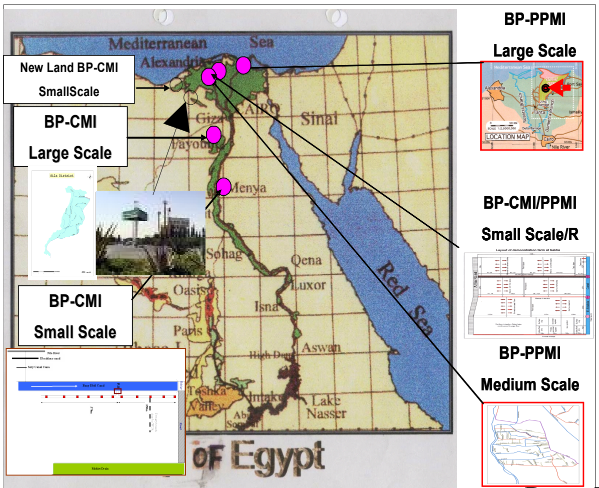
6.5 Potential for Community Based (Small Scale) Irrigation

Agriculture in the country is characterized by increased agricultural productivity, reduced water availability and a growing demand for food. It is now widely recognized by the government that improved water resource management, should be encouraged through the utilization of effective water harvesting techniques. The responsibility for the implementation of successful community based (small scale) irrigation practices lies with governmental and non-governmental agencies, who are supported by local leaders of the beneficiaries. However, many lack sufficient equipment and information on alternative options which are available. Although there might not be water saved through this process in some areas, stability of water allocation provides more water for tail end users.

Water release from the High Aswan Dam (HAD) is based on "indicative" cropping patterns and calendars that are often released months prior to actual planting dates. In many cases this does not reflect the actual crops grown. Liberalization and farmer's free choice have resulted in much more uncertainty about actual irrigation water demands, and many cases of significant "mismatch" have occurred. Reducing agricultural water consumption is an effective measure for increasing water productivity, including the gradual replacement of sugarcane with sugar beet, reduction in rice areas, replacement with short duration varieties of rice and other changes to indicative and actual cropping patterns. In addition to the above, significant problems and constraints hindering the integrated use of water and land are (i) inadequate national and local institutional arrangements including beneficiary organizations (associations, cooperatives) and, (ii) the absence of a long-term government policy and enabling environment..

6.6 Best Practice Sites

Figure 6.3 Location of CMI/PPMI Best Practice Sites



The selected best practice sites in Egypt (Table 6.2 below) involve a range of scheme sizes, most of which do not conform to those found outside the lower Nile Basin in Egypt and Sudan. The best practices are found in the larger scale systems and may have wide applications, but will have to be utilised with care. Farmers in these parts of the Nile have a long history with irrigation and an understanding of it that is passed through the generations. This cannot be said about much of the upper Nile Basin countries. Many things can be taken for granted in Egypt; however, this is not the same case in other countries. Marketing, access and many other key issues are well institutionalised and encourage farmers to irrigate more efficiently than elsewhere. The location of selected sites is given in Figure 6.3.

Table 6.2 List of BP of CBSSI Sites in Egypt

Site Name	Location/Type	Reason for Selection	Site Properties
Bahr El-Nour	Delta Area (PPMI-Large scale)	Controlling water supply from the water source	Example of BP for controlling irrigation water at main canal by (automation),and for the sub-branch canal by (one lifting point)
			Strong formation and operation of WUAs in all levels
			Good management at farm level and economically supported
W/10-Sefsafa	Old land-Lower Egypt (CMI-large scale)	New operation technique from level	New design/operation criteria at sub-branch and tertiary canals (Meska and Marwa), by (electric pumps and improving ditches)
			Using of fresh and drainage water for irrigation (at the end/D.S of the irrigation system in Egypt)
			Pilot area for testing the new irrigation and agricultural practices with good link with different agencies and stakeholders
Sakha	Research Unit-Delta (small scale)	Research centre with cooperation with stakeholders	Good example for the link between users and research activities to help overcoming region's problems
			Place where irrigation and agricultural engineers can test proposed new design/operation criteria.
			Mainly the unit is supporting the local beneficiaries for different new practices like new rice verities and crop rotations
Sela District	Middle Egypt-Fayoum (WUA-large scale PPMI)	Example of cooperation between Gov & users in district level	Activities of large scale operation WUA at district level with proposed cooperation with other agencies and local Gov.
			Example for self-managed organization in all level of operation.
			The place represent the cropping/irrigation condition in Middle Egypt
			Issue of protecting the ecosystem in the area is essential
Bani Abad	Upper Egypt-Menya (Small scale)	BP in Nile valley AEZ with strong WUAs	Good example of small scale and sustainable WUA in tertiary level (operated for 15 years)
			self-finance organisation
			The site represent the lower part of the Nile valley where different cropping pattern is found (case of Sugar-cane, and no rice).
Dina Farm	(small Scale)	BP in New lands (Private sector)	Example of new farming technology & irrigation system in new reclamation lands
			Fully controlled by private investors and serve the local and outside market
			Economic aspects and environmental considerations
			integrated in terms of agricultural and animal production

The results from selected BP sites that could be applied to other Nile Basin countries include:

(a) Head farmers using less water and hours per irrigation reduced;
(b) Reduced labour costs for irrigation due to more efficient water delivery (Crop Budgets);
(c) Improving of cropping patterns and rotations that also reflect external influences such as prices.
(d) Improved crop yields, returns (Table 6.3) and values of land/water;
(e) More significant differences between 'before' and 'after' improvements;
(f) Stronger WUAs with identified roles and responsibilities and rules to resolve conflicts;
(g) Established linkages with other agriculture and irrigation agencies.
(h) Development of financial resources of WUA to improve operation and maintenance.
(i) Increase of the environmental awareness through the transfer knowledge of success cases;

Experience in Egypt has shown that for successful BP on irrigation schemes, (i) political and public support is essential, (ii) realistic investment and service targets are proposed, (iii) appropriate allocation of risks and responsibilities between different parties are agreed, (iv) legal land ownership and water rights are allocated/ defined and (v) appropriate enabling legislations and regulations are in place.

Table 6.3 Total Cost and Returns of some crops in BP sites.

Crop	Yield		Total cost US $/Ha	Total return US $/Ha
	Unit	Main product		
Wheat	Ardab	13	636	1296
Berseem	Cutl	4	318	1789
Cotton	Kantar	5.7	1409	914
Maize	Ardab	17	714	984
Rice	Ardab	3.5	891	1441
Bean	Ardab	7	627	694

7 ETHIOPIA

7.1 Overview

Ethiopia is a heterogeneous country with sharp gradients in rainfall, topography, population density, land uses and soils. Although many CBSSI schemes exist, comprehensive data on the locations, details and benefits is far from complete. Successive programmes have shown the need for improvement of CBSSI throughout the whole country, although within the Nile Basin there have been fewer developments than elsewhere. Priority areas are not established on a national needs base, but by the regional authorities using their own criteria. This approach will meet local and regional needs, but many schemes have a national or export importance, and therefore common and clear criteria need to be established in order to form an integrated approach. The success of CBSSI measures centres on the organisation and involvement of the community, as well as the proximity to identified markets. Those schemes with effective community management have been able to realise significant benefits for their members.

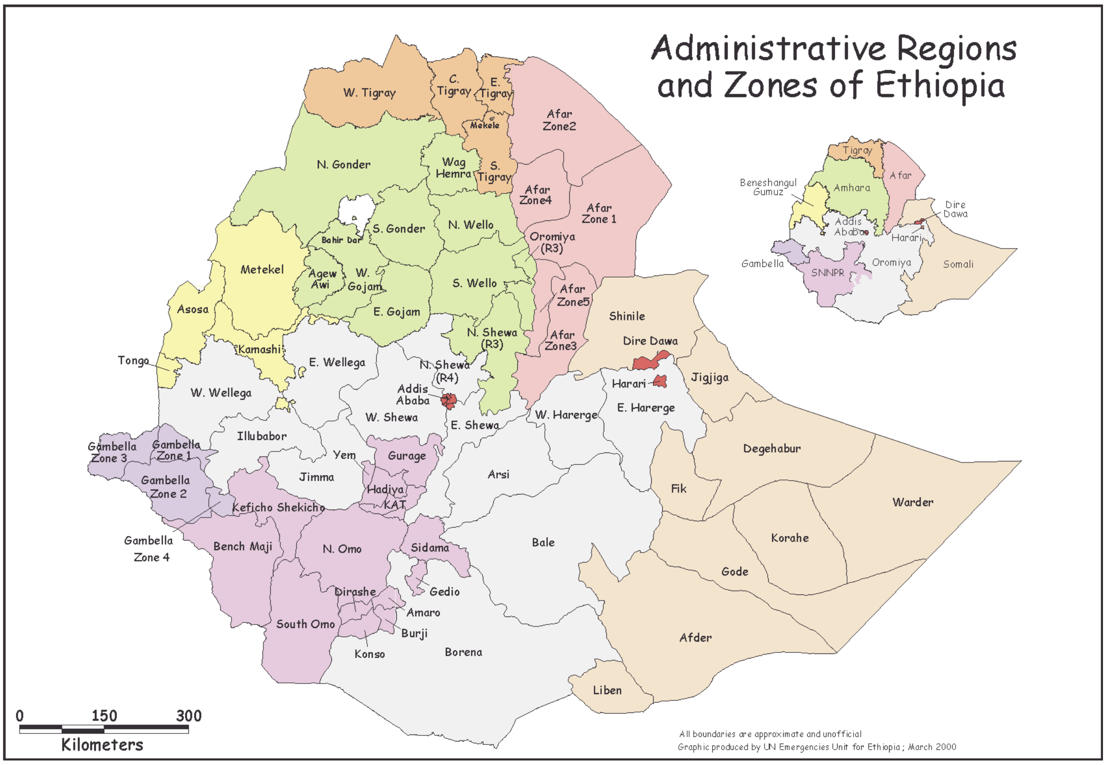
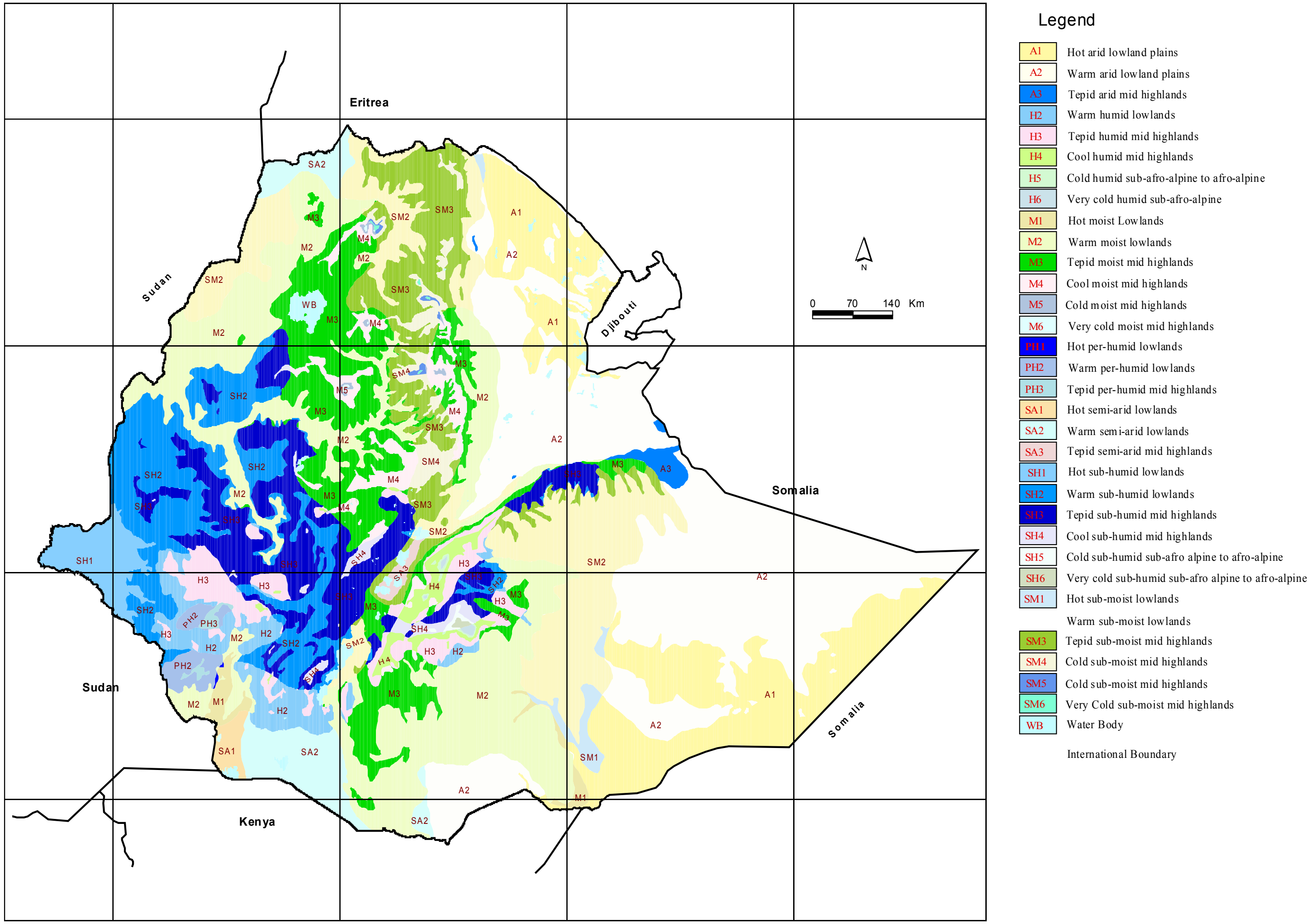


Figure 7.1 Map of Ethiopia

7.2 Agro-Ecological Zones (AEZ) of Ethiopia

The Ministry of Agriculture and Rural Development has delineated 32 major AEZ based on elevation, temperature and moisture regimes (Table 7.1). The location of these AEZ is given in Figure 7.2. In most cases, places at higher elevation receive a higher rainfall amount.

Figure 7.2 AEZ Classification in Ethiopia



7.3 Community Based (Small Scale) Irrigation Sites

Community Based (Small Scale) Irrigation is practiced in all parts of the country irrespective of AEZ to overcome the changes in rainfall patterns, distribution and amounts, as well as coping with increased population pressures and smaller land holdings. Ethiopia has many small scale irrigation schemes, but the successes have been very variable due to technical reasons (inadequately trained engineers at the appropriate level), social reasons (insufficient involvement of the benefitting communities), institutional reasons (unclear responsibilities and too much reliance on external support) and financial reasons (no clear markets or market linkages established). Development/rehabilitation costs have been relatively high due to incomplete or over optimistic estimates. In spite of this, there is still widespread interest in communities who suffer from many constraints that they are unable to overcome with their own limited resources.

Table 7.1 Major Agro-ecological Zones of Ethiopia

Category		Code	Name of the Major Agro-ecological Zone	Area, ha	%, of the Country
1	Arid	A_1	Hot Arid Lowland Plains	12,202,262	10.76
2		A_2	Warm Arid Lowland Plains	22,356,327	19.71
3		A_3	Tepid Arid Lowland Plains	488,137	0.43
		Sub total		35,046,726	30.9
4	Semi-arid	SA_1	Hot Semi-arid Lowlands	444,794	0.39
5		SA_2	Warm Semi-arid Lowlands	3,120,098	2.76
6		SA_3	Tepid Semi-arid Mid Highlands	218,623	0.19
		Sub total		3,783,515	3.34
7	Sub-moist	SM_1	Hot Sub-moist Lowlands	637,273	0.56
8		SM_2	Warm Sub-moist Lowlands	10,894,270	9.6
9		SM_3	Tepid Sub-moist Mid Highlands	5,846,476	5.18
10		SM_4	Cool Sub-moist Mid Highlands	1,314,117	1.17
11		SM_5	Cold Sub-moist Mid Highlands	76,812	.08
12		SM_6	Very Cold Sub-moist mid Highlands	18,018	0.02
		Sub total		18,786,966	16.61
13	Moist	M_1	Hot Moist Lowlands	672,102	0.59
14		M_2	Warm Moist Lowlands	17,147,667	15.12
15		M_3	Tepid Moist Mid Highlands	9,101,092	8.03
16		M_4	Cool Moist Mid Highlands	1,965,932	1.73
17		M_5	Cold Moist Sub-Afro-Alpine to Afro-Alpine	18,823	0.07
18		M_6	Very Cold Moist Sub-Afro-Alpine to Afro-Alpine	15,243	0.01
		Sub total		28,980,959	25.55
19	Sub-humid	SH_1	Hot Sub-humid Lowlands	1,892,953	1.68
20		SH_2	Warm Sub-humid Lowlands	8,046,791	7.09
21		SH_3	Tepid Sub-humid Mid Highlands	7,515,534	6.63
22		SH_4	Cool Sub-humid Mid Highlands	589,026	0.53
23		SH_5	Cold Sub-humid Sub-Afro-Alpine to Afro-Alpine	68,814	0.06
24		SH_6	Very Cold Sub-humid Sub-Afro-Alpine to Afro-Alpine	34,889	0.04
		Sub total		18,148,007	16.03
25	Humid	H_2	Warm Humid Lowlands	2,592,587	2.29
26		H_3	Tepid Humid Mid Highlands	3,065,658	2.7
27		H_4	Cool Humid Mid Highlands	1,069,061	0.94
28		H_5	Cold Humid Sub-Afro-Alpine to Afro-Alpine	62,616	0.06
29		H_6	Very Cold Humid Sub-Afro-Alpine	50,576	0.04
		Sub total		6,840,498	6.03
30	Per-humid	PH_1	Hot Per-humid Lowlands	13,087	0.01
31		PH_2	Warm Per-humid Lowlands	765,363	0.68
32		PH_3	Tepid Per-humid Mid Highlands	152,278	0.13
		Sub total		930,728	0.82
	Water Body			868,040	0.76
	Grand Total			113,385,439	100

The total irrigated area in Ethiopia in 2004, was estimated at 205,842 ha (Table 7.2), which is about 70% of the total equipped irrigation area in the country. This includes both traditional community managed irrigation (CMI) and modern CMI. The data available in the BP reports does not classify these areas into small or medium scale developments according to the Ethiopian established norms. In general, the documentation on the performance of irrigation schemes is incomplete, and instead concentrates on the problems with the SSI, rather than on what has and can be achieved elsewhere.

Table 7.2 Actual Irrigated Area by Regions in Ethiopia (2004)

Region		Irrigated Area under traditional CMI (ha)	Number of Beneficiaries	Irrigated Area under Modern CMI (ha)	Number of Beneficiaries	Total	
						Irrigated Area (ha)	Number of Beneficiaries
1	Oromia	56,807	113,614	17,690	61,706	74,497	175,320
2	Amhara	80,710	450,910	7,410	34,140	88,120	485,050
3	SNNPR	2,000	2,700	11,577	45,000	13,577	47,700
4	Tigray	2,607	25,692	11,270	46,350	12,607	72,042
5	Afar	2,440	16,640	0	0	2,440	16,640
6	Somali	8,200	16,400	1,800	7,000	10,000	23,400
7	Gambela	46	373	70	280	116	653
8	Benshangul Gumuz	400	2,000	200	170	1,696	2,170
9	Harari	812	558	125	71	937	629
10	Diredawa	640	1,536	1,056	3,676	1,500	5,212
11	Addis Ababa	352	8,608	0	0	352	8,608
	Total	155,014	639,031	51,198	198,393	205,842	837,424

7.4 Identified Practices

The impacts of the declining rainfall within many parts of Ethiopia are well known, and this has led to an increase in both formal planned irrigation as well as informal local community initiatives. Over the years, government extension staff have been trained in supporting SSI developments, but in many cases those staff required to support the frontline, do not have the necessary technical expertise to support the farmers adequately. Subject matter specialists are trained to support these staff, but again they are constrained by transport and other logistical aspects, as well as insufficient technical material and training. A long list of Best Practises has been prepared (Table 7.3) and these have been used to identify and rank best practice sites (Table 7.4) with the locations provided in Figure 7.2.

Table 7.3 Long list of Best CBSSI Practices in Ethiopia

Description of Best Practice		Information Source (recommended by)	Location	
			Region	Woreda
1	Surge Irrigation in Vertisols	Mintesinot, B, et al. 2006	Tigray	Mekelle University
2	Effective Traditional WUA in Wonjela CMI	Adgo, et.al.	Amhara	Injibara
3	Effective Traditional WUA in Gedo CMI	Adgo, et.al.	Amhara	Ankesha
4	Low pressure gated pipe	Leul K. 1998	Tigray	All
5	Supplementary irrigation as priority use of harvested water	Leul K. 1997	Tigray	All
6	Low cost canal lining material	Fekadu, Y. 1994	All	All
7	New Crop Varieties	Tsedeke A. (ed) 2006	All	All

Of the CBSSI best practices listed above, several (1, 4, 5, & 6) are not yet proven best practices as they have yet to be adapted by farmers on SSI. In most cases in Ethiopia, success relies upon two key factors: established and strong WUAs and good access to markets.

7.5 Potential for Community Based (Small Scale) Irrigation

Community Based (Small Scale) Irrigation is very important in low rainfall areas with short growing periods where rainfed crops suffer frequent moisture deficits. These include (i) Arid (LGP = 45 days), (ii) Semi-Arid (LGP = 46 – 60 days) and (iii) Sub-Moist (LGP = 61- 120 days). Although the moist AEZ has a satisfactory length of growing period (LGP = 121 – 180 days), with the variation in rainfall amounts and timing, irrigation is still important. This is due to the fact that both supplementary irrigation in the rainy season, as well as permitting farmers to cultivate a second high value crop, complements the food crops grown in the first season. Support for the development of WUAs is an essential part of achieving BP, and the primary success factor has been the commitment and effectiveness of the community leadership and their understanding of the benefits that can be achieved. Support from the Woreda administration and Agricultural offices has also been instrumental in the successes achieved.

7.6 Best Practice Sites

Seven CBSSI sites of good practice have been identified and are listed in Table 7.4 and shown on Figure 7.3.

Table 7.4 Long list of Best Practice CBSSI Sites

Name of Site		Description of the Significant Parameter	Information Source (recommended by)	Location	
				Region	Woreda
1	Mai Negus	Higher application efficiency, income per cropped area and output per unit water	Mintesinot B et. al. 2005	Tigray	Laelay Maichew
2	Godino	Increased income & living standard of Irrigators	IWMI, et. al. 2004; OIDA, 2000	Oromia	Adaa
3	Chole	Good Irrigation management and Strong WUA	OIDA, 2000	Oromia	Ambo
4	Indris	Good Irrigation management and Strong WUA	OIDA, 2000	Oromia	Ambo
5	Taltale	Expansion of irrigable area	OIDA, 2000	Oromia	Ambo
6	Kobo-Alewuha	Good Irrigation management and Strong WUA	Mekuria T., 2003	Amhara	Kobo
7	Burka Weldiya	Deficit irrigation and effective traditional WUA	IFAD, 2007	Oromia	Jarso

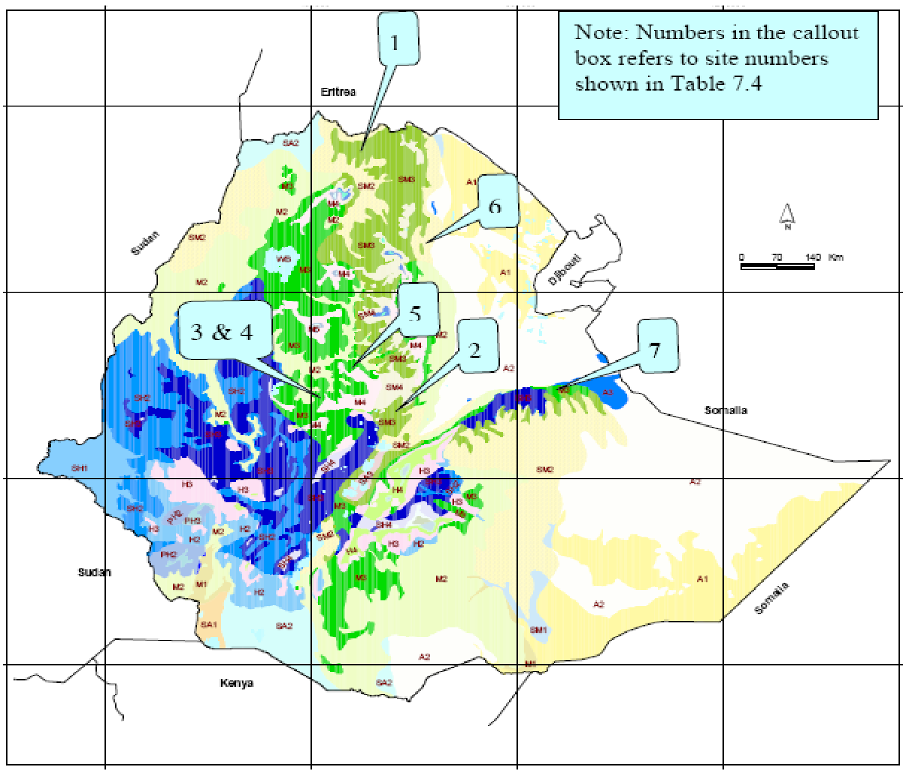


Figure 7.3 Locations of Best Practice CBSSI Sites

The success achieved on CBSSI sites can benefit other schemes in the same areas. In these cases, the BP studies showed that technology and experience transfer is high. Both the Chole and Idris schemes with their strong leadership and cohesive WUAs, together with good water management, appropriate cropping patterns linked to market demands, and high prices have benefitted other SSI in the same area. The Wonjela scheme illustrates this well with strong leadership that over time that has led to an expansion of the 100 year old scheme, to the present command area of 270 ha benefitting 500 farmers. Members of the WUA closely observe the unwritten bylaws and decisions of their elected leader. They all fully participate in maintenance activities, and have a firm stand against water theft. Such attitudes are often not present in Government/NGO initiated schemes. Two CBSSI schemes not included in the above are located nearby to established private irrigation schemes, for growing of sugar and flowers. Both are outgrowers to the main schemes and are successful, as they have an established marketing system combined with ready markets.

Other important lessons which can be drawn from assessment of the best practices for SSI planning and implementation include: (i) the importance of participatory planning, (ii) the organizational arrangement and role of the community, (iii) highly committed community leadership, (iv) good water management, (v) the importance of support efforts of technical staff and administration personnel, (vi) the need for adequate extension support in irrigation agronomy, crop protection, water management and marketing and (vii) a monitoring and evaluation system designed to measure the performance of the above.

Table 7.5 Summary of the Lessons Associated with the BP CBSSI Sites

Region	Site	Area (ha)	Key Lessons
Tigray	Mai Negus (Compared to two scheme in the vicinity)		Relatively better marketing access is the primary factor for the production of more horticultural crops in Mai Negus. This scheme is the major supplier of irrigation produced to nearby towns of Axum, Adwa and Shire with no or little competition from other schemes. Besides, a main highway crosses the irrigable area.
Oromia	Godino	140	Godino is very close to big urban centres such as Debrezeit, Adama, Mojo, Addis Ababa and others. Such proximity to such big markets has contributed for the high income obtained by the irrigators. Lack of integration and coordination of catchment conservation and the irrigation is leading to the loss of the water reservoir and consequently abandonment of irrigation scheme
	Chole	200	The presence of strong WUA and large market (like Addis Ababa) is instrumental for improved water productivity.
	Indris	382	
	Taltale	145	
	Burka Weldiya	70	The farmers practice deficit irrigation (i.e. the scheme was designed for 30 ha but is irrigating 70 ha.) The role of water masters in water allocation and amicable settlement of disputes is considered as helpful.
Amhara	Kobo – Alewuha	380	As the farm is located on the Weldiya – Mekelle main road, the farmers receive competitive price at farm gate. Thus, the farmers are growing more of horticulture crops, and the cropping intensity is 200% with a possibility of a third harvest.

8 KENYA

8.1 Overview

Kenya is a relatively dry country with most of its population concentrated around the wetter central highlands and the Rift Valley. Small scale irrigation has been practiced throughout the country for many years, although on a smaller scale in the Nile Basin. As a result, there are many good examples and areas where CBSSI has continued to be successful in the country. Nevertheless, studies reveal that some of the schemes that used to perform well, have now deteriorated, and this can be attributed to a change in WUA leadership, including inadequate investments to properly maintain the infrastructure.

Kenya covers a geographical area of 582,000 km^2 with 20% being classified as high potential agricultural land (rainfall >1000 mm pa), but carries more than 50% of the country's population. Medium potential land (750 mm – 1000 mm pa) occupies 35% of agricultural land, and carries 30% of the population. The reminder is classified as arid and semi-arid land (ASAL) (mean annual rainfall <750 mm). This is where CBSSI has will play an important role in the future growth and development of the agricultural sector.

8.2 Agro-Ecological Zones (AEZ) of Kenya

Agro-climatic zoning is based on rainfall, elevation and temperature, considering the length of growing season, soil moisture storage and crop water requirements. Seven main agro-climatic zones exist in the country (Table 8.1 and Figure 8.1).

Table 8.1 Agro-climatic zones of Kenya

Zone	r/Eo ratio in % (Aridity index)	Agro-climatic designation	Range of rainfall (mm)	% of total land area
I	> 80	Humid	>2000	4.3
II	65 – 80 %	Sub-humid	1500-2000	4.1
III	50 - 65	Semi-humid	1000-1500	4.4
IV	40 - 50	Semi-humid to semi-arid	700-900	4.9
V	25 - 40	Semi-arid	500-700	15.0
VI	15 - 25	Arid	250-500	21.7
VII	< 15	Very arid	< 250	45.6

Source: Sombroek et.al., 1980

The humid, sub-humid and semi-humid areas are mainly above 1,500 metres above sea level and are characterized by intensive cash and subsistence farming. Large farms and estates with tractor mechanization coexist with small holdings using oxen or hand labour. The major crops produced include tea, coffee, maize, wheat cut flowers, vegetables, fruits, sugarcane, beans and bananas. High grade dairy cattle are common in these areas, but are often stall fed due to shortage of land for grazing. Additionally, improved breeds of sheep, pigs and poultry are also found in these high potential areas. The main forest areas which occupy less than 3% of Kenya's land area, consist of both indigenous and planted trees, and are found above 1,500 metres.. Characterized by mixed crop and livestock farming are the semi-arid areas, whereas the arid and very arid areas are associated with pastoralism and wildlife. Crops grown in the semi-arid areas include maize, sorghum, millet, beans, cow peas, pigeon peas and irrigated vegetables. Cotton and sisal are sometimes grown. ASAL supports 35% of Kenya's cattle, 67% of sheep, goats and all camels.

The main AEZs are divided into sub-zones according to the yearly distribution and lengths of the growing periods on a 60 % probability factor. This means that the given length of the growing period should be reached or surpassed in at least 6 out of 10 years. The growing periods are defined as seasons with enough moisture in the soil to grow most crops.

Table 8.2 Sub Agro-climatic zones of Kenya

Main AEZ	Sub-AEZ							
	0	1 (humid)	2 (sub-humid)	3 (semi-humid)	4 (transition)	5 (semi-arid)	6 (arid)	7 (hyper-arid)
UH (Upper highland zones) Ann. mean 10-15° Seasonal night frost	Forest zones	Sheep & dairy	Pyrethrum & Wheat	Wheat & Barley	Upper Highland ranching	Upper Highland Nomadism		
LH (Lower Highland zones) Ann. mean. 15-18° Norm. no frost		Tea and Dairy	Wheat/ Maize & Pyrethrum	Wheat and Barley	Cattle Sheep & Barley	Lower Highland ranching	Lower highland Nomadism	
UM (Upper Midland zones) Ann. mean. 18-21 ° M. min. > 11-14 °		Coffee and Tea	Maize and Coffee	Marginal Coffee	Sunflower & Maize	Livestock and Sorghum	Upper midland ranching	Upper midland Nomadism
LM (Lower Midland zones) Ann. mean. 21-24° M. min. > 14 °		L. Midland Sugarcane	Marginal Sugar cane	Lower Midland Cotton	Marginal Cotton	L. Midland Livestock & Millet	Lower Midland Ranching	Lower Midland Nomadism
L (Lowland zones) IL (Inner Lowland zone) Ann. mean. > 24° Mean max > 31°		Rice	Lowland Sugarcane	Lowland Cotton	Groundnut	Lowland Livestock & Millet	Lowland Ranching	Lowland nomadism
CL (Coastal lowland zone) Ann. mean > 24 ° Mean max. < 31°		Oil palm	Lowland Sugarcane	Coconut & Cassava	Cashewnut & Cassava	Lowland Livestock and Millet	Lowland Ranching	Lowland Nomadism

Source: Jaetzold and Schmidt 1983

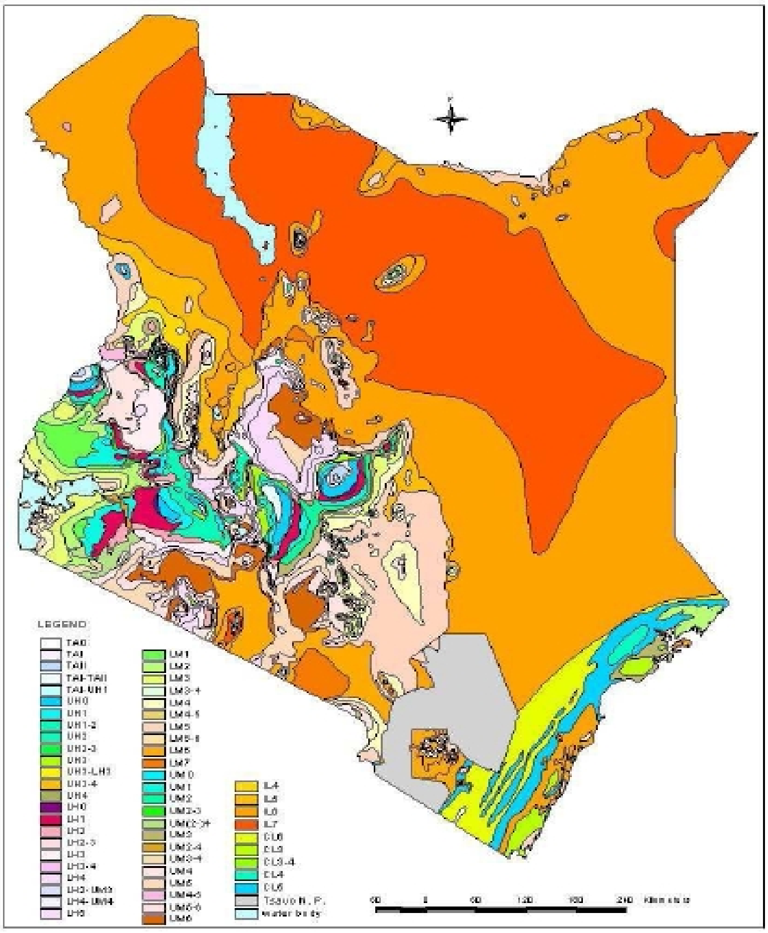


Figure 8.1 Agro-Climatic Zones in Kenya

8.3 Community Based (Small Scale) Irrigation Sites

About 50 % of the irrigated area in Kenya (106,000 ha) is under small scale irrigation. Around 47, 000 ha are under community management comprising of approximately 2,500 schemes. Some schemes have received assistance from the government, NGOs or international organizations in the past. It is estimated that 15,000 ha is operated by individual farmers, whilst the remaining area is community managed. In the BP study, information was obtained on 49 irrigation schemes in Nyanza, Rift valley and Central provinces. In the context of community management, consideration needs to be given to those schemes that are currently under government management in conjunction with the communities, and which are due for full handover in the near future. In Kenya, schemes are classified according to the management system operating, and this would therefore seem an appropriate approach. The management of these schemes is more complex as they involve large communities and greater volumes of crop output that requires high level marketing strategies. Water distribution, operation and maintenance require more formal organizations and full representation amongst stakeholders. Information was provided on 7 public irrigation schemes in the Lake Basin, Rift valley, Central and Coast provinces.

8.4 Identified Practices

CBSSI practices have been carried out in many parts of the country and have had an impact in increasing crop yields, contributing to poverty alleviation and an increase in food security. A list of BP and technologies in irrigation are given in Table 8.3.

Table 8.3 Long List of Best Practices in Irrigation in Kenya

Irrigation practice	Method used	Comment
Surface irrigation systems		
Pump fed (Basin)	Water is pumped from the source and directed to basins prepared for planting.	Distance from water source to irrigated field adjustable depending on topography and energy required for pumping.
Pump fed (Furrow)	Water is pumped from the source and directed to furrows in the field prepared for planting.	Distance from water source to irrigated field adjustable depending on topography and energy required for pumping.
Gravity (Basin)	Water flows by gravity from the source through a main canal and directed to prepared basins in the field.	Distance from water source to irrigated fields will vary depending on topography.
Gravity (Furrow)	Water flows by gravity from the source through a main canal and directed to prepared furrows in the field.	Distance from water source to irrigated fields will vary depending on topography.
Overhead irrigation systems		
Gravity fed sprinkler system	Pressure depends on the elevation difference between the water source and the irrigated fields. Pressure not adjustable.	This is a gravity system requiring no pumping. Initial cost is high but running cost and maintenance is minimal.
Pump fed sprinkler system	Pressure depends on the type and number of sprinklers, The pumping head from the source to the irrigated fields and the pump capacity. Pressure can be adjusted to suit specific requirements.	High energy requirement for pumping. Need high value crops for economic returns.
Drip irrigation system		
Low head drip irrigation	Small drip irrigation kits for vegetable growing near homestead. The size of water container and number of laterals will depend on the size of plot under irrigation.	The system has become very popular and being promoted in several areas in Kenya. It is affordable by most small scale farmers.
High head drip irrigation	Large drip irrigation system with either pumping or high head.	The system is suited for commercial farming with high value crops to pay off the high operational cost.

The greatest challenge in CBSSI is the need for stable and organized markets. The level of management in many CBSSI is low but with government support in management and infrastructural development, they have proved sustainable. Gravity fed system has been more sustainable than pumped systems. Some CMI schemes have strong co-operative societies that are actively involved in the running and management of irrigation operations. In Table 8.4, a list of the best practices found in CBSSI is provided.

Table 8.4 Long List of Best Practices in CBSSI in Kenya

Description of Best Practice	Percent of schemes evaluated	Water source	Region

1	Pumping with diesel pumps (basin, furrow)	42	Lake Victoria	Nyanza
2	Gravity (basins)	22	River	Nyanza
3	Gravity (furrows)	20	River	Nyanza
4	Treadle pumps	9	Lake Victoria	Nyanza
5	Hand pumps	2	Lake Victoria	Nyanza
6	Bucket	2	Lake Victoria	Nyanza
7	Pump fed sprinkler system	1	Lake Victoria	Nyanza
Other practices				
8	Gravity fed sprinkler system		River	Central
9	Supplementary irrigation using harvested water		Depends on water harvesting structure	All

8.5 Potential for Community Based (Small Scale) Irrigation

The Kenya government is committed to the devolvement of management to the communities, and also to the provision of training and support in the handover process. Insufficient attention in the past has been given to the time that this takes, and also the need to incorporate improvements in water productivity at the same time. Close attention to markets and crops grown are essential for the improvement of agricultural production, with any handover being coupled with investments and improvements in the infrastructure. Water is a limited resource in many areas and requires a basin management approach, to ensure equitable use and sharing between its multiple users. The success of irrigation projects generally depends on the involvement of the concerned communities, as well as a comprehensive analysis of the technical, economic, social and environmental factors. There are some irrigation practices/technologies that have been successfully implemented in some environments, but have not been properly documented. This limits the scaling up or their adaptation in other areas with similar environmental conditions.

8.6 Best Practice Sites

Best practice in Kenya is considered as giving optimum utilization of land and water resources for sustainable agricultural production and environmental management. The criterion for the selection of best practices was established, and the selection of the best practice based on the evaluation of salient features on a scale of 1-10. Final selection of best practice was done by developing a matrix of the salient features. The results are given in Table 8.5.

Table 8.5 Identified Best Practice CBSSI Sites in Kenya

Best Practice site CBSSI	Rank
Mitunguu (Meru central district)	1
Kibirigwi (Kirinyaga district)	2
Alanyahoda (Nyando district)	3
Asunda (Nyando district)	4
Alungo (Nyando district)	5
Ngura (Homa bay district)	6
Wahambla (Homa bay district)	7
Abwao (Nyando district)	8

Note: For more details see David M. Mburu, Report on Best Practices and Best Practice Sites in Water Harvesting and Irrigation in Kenya. May 2008.

Similarly, the prioritization of the best practice site for schemes that will soon be reclassified as CBSSI after handover from Government is given in Table 8.6. The same basis was used as for the CBSSI schemes given in Table 8.5 with the highest number of points scored being considered the best practice site.

Table 8.6 Identified Best Practice in Public Managed schemes in Kenya

Best Practice site Public Managed schemes	Rank	Best Practices on site

Mwea (Kirinyaga district)	1	Good data management on river and canal discharge. Involvement of water users association in day to day running of the scheme. Capacity building of farmers in best practices on irrigation water management. Monitoring and evaluation of scheme activities. Good marketing strategy to ensure sustainability. Good co-ordination amongst all stakeholders
Perkera (Baringo district)	2	
Bunyala	3	
West Kano (Nyando district)	4	
Bura (Tana River district)	5	
Ahero (Nyando district)	6	
Hola (Tana River district)	7	

The study on Best Practices has shown that for all schemes listed in Table 8.5 and 8.6, the strength of WUAs, availability of market and established linkages, is an essential part of the success. The key factor has been the commitment and effectiveness of the community leadership, and their understanding of the benefits that can be achieved. This includes the close working arrangements with Government officers to establish viable and secure markets. Other factors include: (i) active involvement of beneficiaries in decision making and day to day running of the project through their elected leaders in the project area. This has raised their sense of ownership and sustained the productivity of the scheme, (ii) if there is no clear maintenance strategy, scheme operation will be below the design capacity, due to inadequate water reaching the fields, (iii) use of locally available materials and trained personnel in the fields of engineering, quantity survey will reduce the overall construction cost, (iv) use of technically qualified people in construction and maintenance of the irrigation facilities, and agronomic practices helps in maintaining high crop yields, (v) where O&M has involved the training of farmers and cooperative society members, a much clearer understanding by the farmers results and contributes to well maintained facilities.

9 RWANDA

9.1 Overview

Rwanda is an equatorial country with high rainfall, high population densities and steep slopes. Data and information on best practices is not well documented due to political instability in the past,. There is an increasing need to provide a complete inventory. Irrigation is not widely practised, but evidence of best practise does exist. Despite the steep land slopes and high population densities, the erosion levels are less than would be expected and in spite of steep land slopes and high population densities, erosion levels are less than would be expected. Government is committed to improving the uptake of CBSSI and is being supported on a number of schemes by Government and international agencies. There is little experience in the development of water users associations in the country and recent developments have tended to comprise engineering activities with full community participation taking second place. There is a will to change this, but information and good professional guidance is needed by the decision makers.

9.2 Agro-Ecological Zones (AEZ) of Rwanda

Twelve Agro-Ecological Zones are recognized in Rwanda (Table 9.1 & Figure 9.1).

Table 9.1 Agro-Ecological Zones (AEZ) of Rwanda

AEZ		Description
1.	Imbo	The Imbo, located in Southwest Rwanda, is the smallest agro-ecological zone. Its centre, made up by the alluvial valleys of the Rusizi and Rubyiro (Congo basin), includes the lowest point of the country, at an altitude of 970 m. A series of mountain ridges however, attaining an altitude of 1,400 m characterize its borders. An average temperature of 24 °C and a dry season of 3 months characterize the tropical climate conditions. The annual rainfall totals increase considerably from about 1,050 mm in the South to 1,600 mm in the North. The high temperatures and abundant rainfall together with the good quality alluvial soils, and the possibilities for irrigation offer many possibilities for an intensive and productive agriculture. Indeed, one of the best practice sites of irrigation is located in that AEZ (Bugarama project).
2.	Impara	The Kivu Lake, the Imbo and the forest on the Congo-Nile Mountain Ridge border the second agricultural zone of the Impara. Its altitude ranges between 1,400 and 1,900 m. With increasing altitude, the annual rainfall increases from 1,300 to 2,000 mm, while the temperature decreases from 22 °C to 19 °C. The very fine clay soils, developing from basalt, have a high agricultural potential at least if they are not leached out by the abundant rainfall. The mild climate, associated with abundant rainfall, generates optimal conditions for the cultivation of a number of traditional and industrial crops.
3.	Kivu Lake Borders	The shores of the Kivu Lake, extending from an altitude of 1,460 m near the lake up to 1,900 m on the western slopes of the Congo-Nile mountain chain, constitute the third agricultural zone. The lake tempers the climate of the region, characterised by temperatures ranging between 19 and 22.5 °C and an average annual rainfall of between 1,150 and 1,300 mm. Nevertheless, within the agricultural zone, clear differences in rainfall amounts have been recorded. The South and North are clearly more humid than the central region of Kibuye. With respect to the soilscape, moderately fertile soils developing on shales and granites have been recorded on the gently sloping hillsides, while the abrupt slopes are strongly eroded, leaving skeletal soils.
4.	Birunga	The agro-ecologic zone of the Birunga groups the volcanic soils that descend from the limit of the national park at an altitude of 2,500 m to an altitude of 1.900 m near Ruhengeri and even below 1,600 m near Gisenyi. Regularly distributed rainfall, varying from between 1,300 and 1,600 mm and fertile soils create favourable conditions for agricultural production. Limitations due to the generally limited soil depth have been removed by cultivating the crops on small ridges created when ploughing or harrowing the fields.
5.	Congo-Nile Watershed Divide	The fifth agro-ecological zone occupies the highland area, extending from the Nyungwe forest in the South to the Gishwati forest in the North that divides the country into two watersheds. All rivers on the left side of this mountain chain drain into the Congo River, while all rivers on its right side drain into the Nile. The lower altitude boundary is 1,900 m, which corresponds to the altitude above which most crops of the tropical lowlands are badly adapted. The tops of the mountain chain surpass an altitude of 2,500 m. In the North, the annual rainfall varies between 1,300 and 1,500 mm, while in the South annual rainfall totals of between 1,400 and 1,800 mm have been recorded. On the mountaintops in the Nyungwe forest, it rains more than 2,000 mm annually. This abundant rainfall has totally leached the soils that were developing from poor parent materials such as sandstone, quartzite, quartzophyllite and granite. Where the forest has been cleared, also the mineral reserves of the litter layer are rapidly consumed and poor soils are left. Although the inhabitants improve the soils near their residence and cultivate several traditional crops, this region is inclined towards forestry. .
6.	Buberuka	In the North of Rwanda, high altitude plateaus traversed by quartzitic chains that attain an altitude of 2,300 m,

	Highlands	characterise the agricultural zone of the Buberuka Highlands. Its lower altitudinal limit corresponds to 1,900 m. It rains about 1,200 mm annually and there is a dry season of 2 months. The soils of this region are generally more fertile than those of the Congo-Nile Watershed Divide, leaving more options for agricultural production. Nevertheless, also in this region, the potential for forestry is high.
7.	Central Plateau	The large region of hills and valleys between the Congo-Nile mountain chain and the Granitic Ridge, at the centre of the country, is referred to as the Central Plateau. At an average altitude of 1,700 m, the annual rainfall amounts to 1,200 mm, with an average temperature of 19 °C. If the humus-bearing horizons are conserved, the soils can be used for the cultivation of a whole range of climatically adapted crops.
8.	Granitic Ridge	The agricultural zone of the Granitic Ridge differs from the Central Plateau because of its soils developing on granitic material. Its average altitude is 1,600 m and the annual rainfall is about 1,100 mm. The convex ridges and rounded, gravelly hills are used for pasture and forest. Crop cultivation is mainly concentrated on the concave hill slopes.
9.	Mayaga	The Mayaga constitutes a narrow agricultural zone, extending over the two borders of the Akanyaru River. In the northern part, the landscape is characterised by hills and valleys that are regularly inundated. The altitude varies between 1,350 and 1,500 m. The landscape of the southern part is much more abrupt, rough and dominated by quartzite chains. Next to differences in topography, the southern part is also characterised by slightly higher annual rainfall totals, varying between 1,100 and 1,200 mm. In the North, it rains about 1,000 to 1,100 mm annually. Also the soilscape is strongly variable. Rock outcrops characterise the hill tops. Humus-rich, gravelly soils are found on the upper slopes, while the younger soils of the footslopes generally have a higher productivity.
10.	Bugesera	The Bugesera is a large plateau located at an altitude of 1,300 to 1,500 m and bordered by the fluvial depositions of the Nyabarongo. A more recent erosion cycle superimposed a new drainage system and resulted in a landscape of smaller isolated plateaus with deep strongly weathered soils, intersected by dry valleys with very gentle slopes. From a climatic viewpoint, this agricultural zone is dry and warm, characterised by an annual rainfall varying between 850 and 1,000 mm, a dry season lasting for three months and an average temperature of about 21 °C. The best soils for crop cultivation are found on the colluvial deposits bordering the marshes and lakes. Nevertheless, the agricultural potential of this region is generally low and the region's main economic activity is pastoralism.
11.	Eastern Plateau	North of the Bugesera, Delepierre (1974) defined the agro-ecological zone of the Eastern Plateau. This vast zone, located at an altitude of about 1,500 m is in fact the extension of the Central Plateau into the drier East. The landscape is characterised by hills with large, horizontal tops and steep slopes. In the eastern part of this region, enormous quartzite ridges cross the landscape. It rains about 900 to 1,000 mm annually. The hilltops are covered with deep humus-rich soils. On the convex upper slopes, outcropping laterite crusts and gravelly soils have been reported. The fields on the steep slopes are strongly eroded and are mainly used as pasture land. In the East, shallow degraded soils dominate the soilscape and only the soils of the footslopes have some agricultural potential.
12.	Eastern Savannah	All the lowlands in the extreme East of Rwanda belong to the Eastern Savannah. This agro-ecological zone is characterised by a gently sloping landscape, with hills that are intersected by large valleys. The altitude generally varies between 1,250 and 1,600 m. Climatically, the region is warm and dry. The average temperature is about 21 °C, while the erratic rainfall amounts to less than 900 mm annually and the dry season lasts for 4 months. The best soils of the region are those with some vertic properties, found in the large valleys. Nevertheless, they still require some important investments in irrigation and machinery. As such, this region is inclined towards pastoralism. .

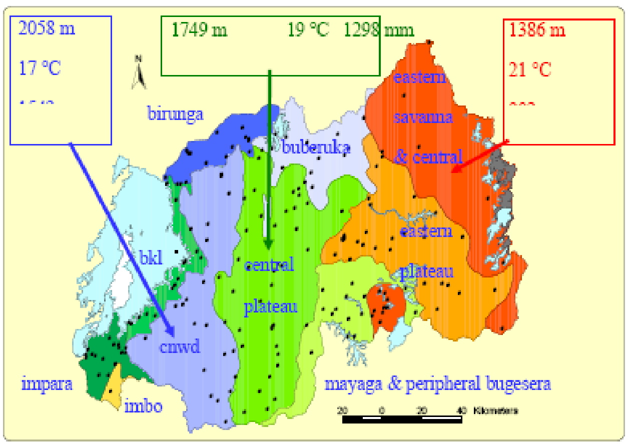


Figure 9.1 Overview of Rwanda Climate

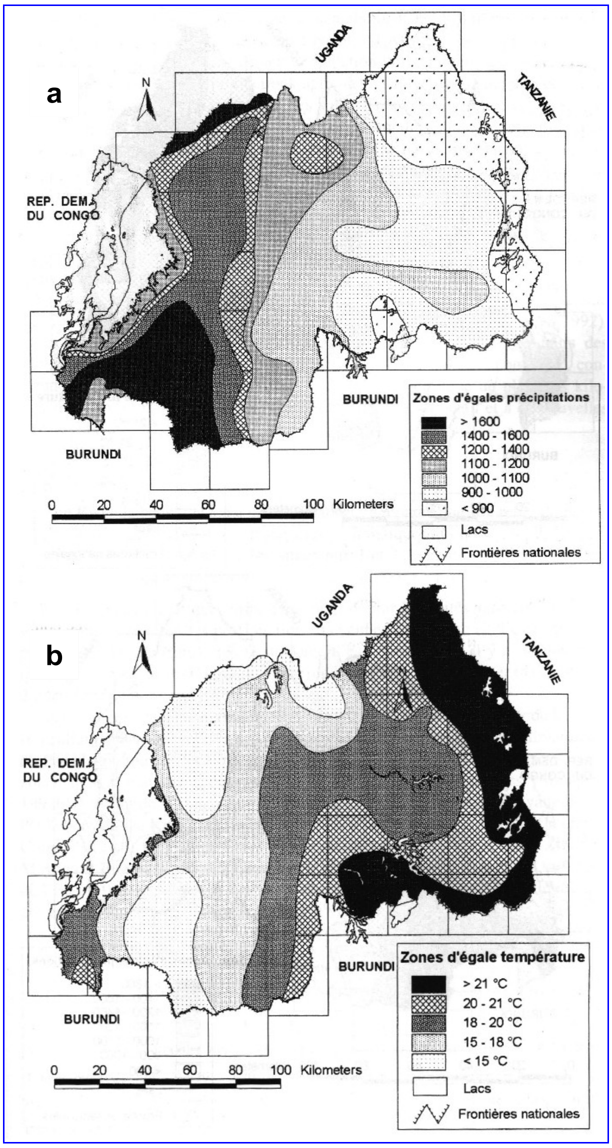


Figure 9.2 Rainfall and temperature of Rwanda

9.3 Community Based (Small Scale) Irrigation Sites

Irrigation has been practiced in Rwanda since the 1960s. The initial developments involved gravity irrigation in the marshlands. More recently, drip and sprinkler irrigation have been introduced but mainly on private schemes. Most of the irrigation schemes in Rwanda are managed by both community and public authorities. No large scale irrigation exists in the country. A list of sites is provided in Table 9.2 although because of the periods of turmoil in the recent past, full details are not available.

9.4 Identified Practices

Development of wet lands (Marais) has formed the basis for irrigation and drainage development in Rwanda. Extensive areas of peat swamps have been utilized for the cultivation of food crops, vegetables, including tea in the North of the country. Most of the techniques used involve a careful control of water tables supplemented by additional water applications in the dry season. Rice is the most common crop to be grown in the wetlands, but with the use of raised beds and water control structures, a much wider range of crops can be grown. Sprinkler irrigation is used Kigali, Nyacyonga and in Bugesera on both private and publicly managed schemes. However, this is on a relatively small scale for crops grown during the dry season. In addition, drip irrigation is used on a small scale mostly in the private sector, but government is promoting its use for flowers (roses), vegetables (tomato, snow peas, and baby corn), essential oil (pacuri, geranium) and fruits (maracuja, Papaya, macadamia, avocado-hass variety, pineapple.

Table 9.2 Long list of irrigation sites in Rwanda

Site name	Cell	Sector	District	Province
Biringanya				South
Munyazi	Nyanza		Huye	
	Rukira			
	Nkima			
	Sovu			
Rwasave		Mbazi	Huye	
		Kibirizi	Gisagara	
		Save		
Mukunguri			Ruhango	
Site name	Cell	sector	District	Province
Rugeramigozi 1 (Public/Private/Community)	Gahogo	Rugeramigozi	Muhanga	South
Gahenerezo (Public)	Gahenerezo	Ngoma	Huye	
Rwasave 1		Ngoma	Huye	
Kanyonyomba			Gatsibo	East
Gakirage		Nyagatare	Nyagatare	
Gashora			Bugesera	
Nasho				
Codervam-Ngarama			Muvumba	
Nyacyonga (sprinkler)	Nyacyonga		Gasabo	Kigali
Kabuye	Mulindi		Gasabo	Kigali
Mulindi (sprinkler)				Kigali
Nyacyonga (drip Irrigation			Gasabo	Kigali

9.5 Potential for Community Based (Small Scale) Irrigation

Although the country has higher rainfall distribution patterns compared to many within the Nile Basin, periods of water shortage and moisture deficit are experienced in most AEZ, especially in the drier south western areas. CBSSI thus has an important role, but the upscaling of the available practices is constrained by a lack of training and knowledge by extension staff and the private sector. This is further exacerbated the limited availability of guidelines and manuals.

9.6 Best Practice Sites

Five sites are presented in the National report on CBSSI Best Practice (Table 9.3). The sites mainly involve storage dams with surface irrigation of former seasonal marshland areas.

The major limitations of best practices that have been identified include: (i) a lack in human resources capacity, (ii) poor extension coverage from government due to high costs of field visits (iii) farmers are struggling with water control due poor technology (iv) low soil fertility and land mismanagement contributes to low agricultural production, (v) high labour inputs not available to resource poor farmers (vi) conflict of stored water use between livestock and agriculture in eastern areas where livestock is the predominant activity and, (vii) buffer zones required under environment protection guidelines that results in loss of valuable and scarce agricultural land.

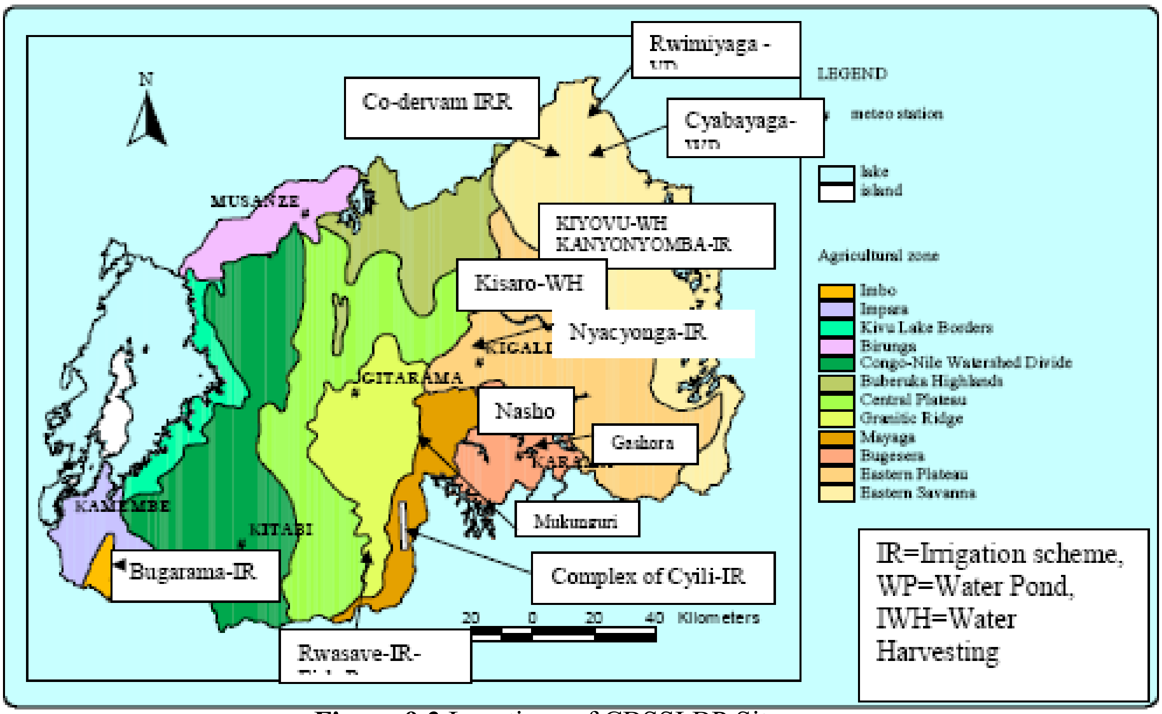


Figure 9.3 Locations of CBSSI BP Sites.

Table 9.3 Ranking of BP CBSSI Schemes

Sites	Technical factors (15)	Economic Factors (24 points)	Possibility of Environmental status factor (12 points)	Ease of implementation (5 points)	Social factors (24 Points)	Regional condition (20)	Water use efficiency (6)	Total	Rank
Bugarama	12	22	11	3	22	18	5	93	1
Kanyonyomba	10	14	10	3	18	16	3	74	2
Complex of Cyili	9	13	7	3	18	13	2	65	3
Nyacyonga	10	12	9	4	12	15	4	66	4
Rwasave	9	12	7	3	17	13	2	63	5

10 SUDAN

10.1 Overview

Although production and export of oil are growing significantly in importance, agriculture still remains the major source of income for most of Sudan's population, 70% of who live in rural areas. From 2002 to 2006, agriculture contributed between 39% and 46% to the country's GDP, employed 57% of the total economically active population, and contributed about 90% of the non-oil export earnings. Sorghum is the principal crop grown in Sudan, and livestock, cotton, sesame and groundnuts comprise of the major agricultural exports. In addition, 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%.

Agriculture is generally divided, based on the source of water, to irrigated and rain-fed. 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). The total area of the rainfed sub-sector amounts to about 15 million ha depending on the rainfall. These areas lie south of Isohyet, and extend to the southern borders of the country where the mean annual rainfall amounts to 1500mm. This sub-sector contributes to about 70-80% of sorghum produced, almost all the millet and all the sesame, and 60-70% of produced groundnut.

The total irrigated area is about 2 million ha and includes the Vertisols of Eastern and Central Sudan, the banks of the Nile (Blue, White, and main Nile) the Tokar and Gash deltas and Abu Habil. The irrigated sub-sector contributes 10-13% of the country's GDP, including 100% of sugar, 99% of cotton, 20-30% of sorghum, 30-40% of groundnut produced in the country. Other crops grown under irrigation include wheat, vegetables, legumes, fodders, sunflower and maize. The sub sector is characterized by its stable production that forms a unique combination with the rain fed sub-sector, and has played a key role during drought years. Irrigated agriculture can be divided into traditional and modern based on technology used. The former is practiced along the banks of River Nile mainly in Khartoum, Nile, and Northern States.

The rainfed sub-sector is characterized by its huge potential for expansion in area and productivity using new and improved technologies, especially as the past investments has been very low compared with the irrigated sub-sector. Rainfed sub-sector is divided into two types: mechanized and traditional. The mechanized sub-subsector uses tractors, disc harrows, mechanical seeders, combined harvesters and herbicides and is located on the central clay plane of eastern, central, and western Sudan, south of the 500 mm rainfall line. The traditional sub-sector uses a labour-intensive system which includes the use of hand tools, and is located in the west, south and north east of the country.

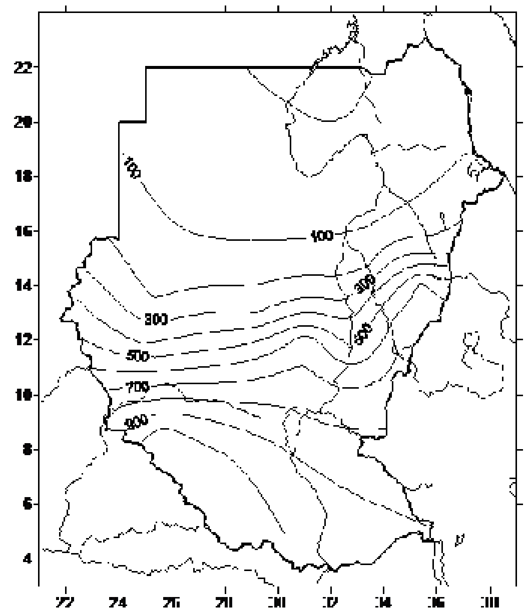


Figure 10.2 Mean annual rainfall in the Sudan (mm)

10.2 Agro-Ecological Zones (AEZ) of Sudan

The country is divided into six AEZ (Table 10.1). In the low rainfall Savannah zone, irrigated agriculture dominates but traditional farming also takes place on clay soils to grow sorghum and sesame. On the sandy soils millet, sesame, groundnuts, roselle and water melon are grown. Large scale commercial mechanized rainfed farming is practiced in this AEZ, particularly towards the southern part. Zero tillage is used in these areas. Traditional cultivation and mechanized farming are practiced in the high rainfall savannah AEZ, with two crops produced annually in the south west due to bimodal rainfall pattern. In the Sudd, where the land is flooded to different degrees and for variable periods, flood water harvesting using residual moisture is practised and has given rise to a mixed economy of herding, traditional cultivation, fishing and hunting. Main crops grown are maize, sorghum, cowpeas, tobacco and pumpkins.

Table 10.1 Ecological Zones of the Sudan*

Zone	Sudan % of area	Mean annual Rainfall (mm)	Wet season	Dry season	Main land use types
Desert	28.9	<75	July-September	October -June	- Irrigated agriculture - Grazing along seasonal water courses
Semi-desert	19.6	75-300	July-Sept November-Jan	November-June March-Sept.	- Irrigated agriculture - Dry land farming in conjunction with water harvesting-Pastoral
Low rainfall savannah	27.6	300-800	May-September	November-April	- Irrigated agriculture - Rain-fed traditional cultivation - Mechanized farming - Pastoral - Forestry
High rainfall savannah	13.8	800-1500	April-October	December-February	- Rain-fed traditional cultivation - Mechanized farming - Pastoral - Forestry
Flood region	9.8	600-1000	May-October	December-April	- Traditional cultivation - Pastoral - Wild life
Mountain vegetation	0.3	300-1000	Variable	Variable	- Traditional cultivation - Pastoral - Forestry – Horticulture

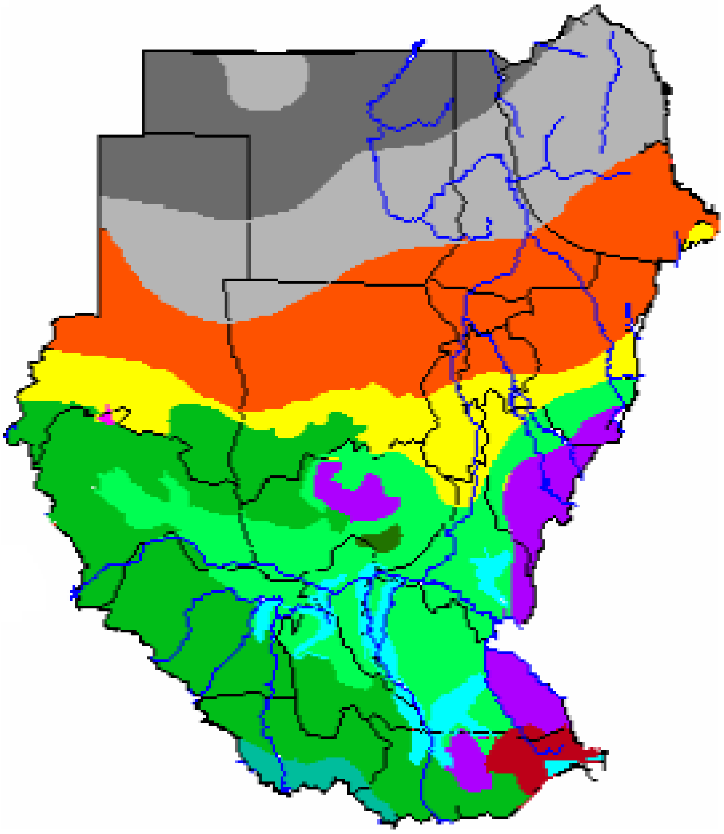


Figure 10.3 Agro-climatic Zones of Sudan

10.3 Community Based (Small Scale) Irrigation Sites

Due to the diversity of climatic zones, soils, and farming systems a wide range of irrigation systems are found in the Sudan. These irrigation systems could be classified according to type of delivery of water from source to final field to three main categories: pump, gravity, and flood[50] (Figure 10.4).

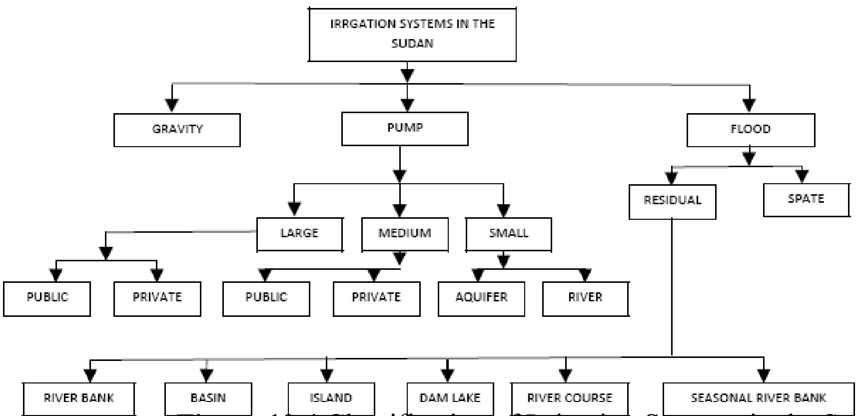


Figure 10.4 Classification of Irrigation Systems in the Sudan

[50] Included under Water Harvesting – see Part I - Best practices in Water Harvesting; Part II - Guidelines for the Implementation of Best Practices in Water Harvesting; Part III - Action plans for possible investments to be considered by the SAPs. Ian McAllister Anderson, Dr Martin Burton, October 2008.

These categories are further divided according to size, source of water, or final field type.

(a) Public and private large pump systems (> 20,000 ha).
(b) Medium irrigation pump systems (20,000 ha to 420 ha)
(c) Small pump schemes (< 420 ha).
(d) Gravity irrigation (including the Gezira scheme - the largest irrigation system in the world under one management).

Community Based (Small Scale) Irrigation in Sudan will include the small pump schemes where farmers sometimes share the same pump, or the pump is owned by an individual but farmers are sharing and managing the water distribution by themselves. Large numbers of small size irrigation projects privately owned are found along the Blue Nile, White Nile, and the main Nile. Farmers have the freedom to cultivate what they decide and crops include field crops, vegetables, and fruit trees. The cost of water delivery is collected as cash or sometimes in kind as a share of the harvested crop. The other category of pump schemes uses small diesel or electric driven pumps pumping directly from aquifers. These are privately owned and widely spread throughout Sudan in the desert, light and heavy Savannah zones.

Although the gravity systems are mostly on very large schemes, there are some aspects of the management that will have application elsewhere, with careful adaptation, to smaller irrigation systems. After the implementation of the Gezira Act for 2005, the management of the lower irrigation system (minor canals and field canals) was allowed to be transferred to farmers groups in the form of water user associations (WUA). These associations will maintain the canals, control weeds, clean sedimentation, and distribute water to farmers. The cost of management will be paid by farmers and fees will be collected by these associations. At the moment, the Gezira Scheme is passing through a transitional stage during which preparatory activities such as capacity building of farmers and preparing the irrigation system to be handed to the WUAs are ongoing on.

No detailed information has yet been provided on CBSSI sites as this report was commissioned much later than the other National reports.

10.4 Identified Practices

In traditional irrigated agriculture, both surface and flood irrigation are practiced. Tillage operations are performed by animals as well as tractors. Seeding, weeding, and harvesting are manually performed. Recently small stationary threshers were introduced to thresh wheat, sorghum, and legumes. Fertilizers and pesticides are used in a limited manner. In modern irrigated agriculture, higher levels of mechanization are practiced (seed bed preparation, seeding, harvesting, and pest management using tractor mounted field sprayers as well as knap sack sprayers). Recommended levels of inputs are largely adopted and used in modern irrigated agriculture (improved seeds, fertilizers, herbicides, pesticides, and growth hormones in sugar projects). This includes the use of a wide range of irrigation systems (surface irrigation, furrow irrigation, long furrow irrigation, gated pipes, drip irrigation, centre pivot and linear sprinkler systems).

A number of CBSSI Best Practices are identified and are included in Table 10.2 below. In addition to this, there is wide experience of improved irrigation methods on Public/Private Managed large scale irrigation schemes, which could have applications and be adapted to the more progressive community schemes (Table 10.3). With the in-country experience, it is easier to transfer such technologies as farmers and beneficiaries have the chance to speak to their own countrymen on the benefits and draw backs of these systems as well as the costs.

Table 10.2 Identified CBSSI Best Practices in Sudan

Best Practice		Description
1	Surface irrigation	Practiced in almost all irrigation systems except flood systems. Depending on the type of cultivated crop, the tilled land is either left flat, or shaped in ridges or beds. Ridges vary in width between 60 cm to 90 cm, while beds vary from 1.0 m to 1.5 m.
2	Basin irrigation	Practiced in locations where there are low lands inundated by the Nile during the flood season. This is found in Seleim Basin in Northern State, in Salawa and Wad Hamid Basins in Nile state. Farmers in these basins collectively organize themselves, work together to facilitate flood water movement in their lands. After water resides, crops such as wheat, legumes, fodders, and vegetables are sown. No additional irrigation is needed. Recently, small pumps were introduced to supplement basin irrigation. In some place like Seleim (North State) large pumps replaced the traditional basin irrigation.
3	Spate irrigation:	Three locations practice large flood or flush or spate community managed irrigation in Sudan. These are Gash in Kassala State irrigated by Gash River, Tokar in Red Sea State irrigated by Khor Baraka, and Abu habil in North Kordofan state. The roaring water from the seasonal rivers is directed by diverting structures dykes and canals to flood demarcated areas. The irrigable area is decided every year by the volume of water carried by the river. This area is divided by the community in a well defined system by the tribes to farmers. Farmers perform the seeding operation and control weeds using manual tools. The crop grows on residual moisture in the soil and no irrigation is needed. Sometimes two crops are grown in one season. Cultivated crops include sorghum, millet, vegetables, watermelons, and recently sunflowers were introduced to these areas.
4	Flood irrigation on river banks	Traditional flood irrigation takes place on banks of rivers, mainly the Nile, in Khartoum, Nile, and Northern states. During the flood season, water covers the cultivated agricultural land for some time and then resides. The period of inundation varies with seasons depending on the flood. After the end of the flood, the soil is covered with a water saturated silt layer. Farmers using hand tools, perform seeding operations. The majority of these lands are privately owned.
5	Flood irrigation on seasonal rivers banks	After flooding of seasonal streams such Atbara River, a flood plain is formed. This plain is cultivated by individual private farmers to grow sorghum and vegetables. The same technologies used in flood irrigation on rivers are adapted here
6	Flooded islands	A number of islands on the main Nile north of Khartoum practice flood cultivation. These islands are inundated by water totally or partially during the flood season. After the flood, farmers use residual water to cultivate legumes, field crops, and cereals, in addition to aromatic and medicinal crops. Sometimes supplementary irrigation is applied using pumps.
7	Seasonal streams water courses	This takes place after the end of the season in some seasonal streams and tributaries of the Nile, such as Dinder and Rahad in Eastern Sudan, and in some Wadis of Eastern and Western Sudan. Farmers use residual soil moisture to cultivate vegetables and fruits mainly tomatoes, cucurbits, and legumes.
8	Banks of (Reservoirs):	After the emptying periods of, Roseires, Sennar, and Jebel Aulia reservoirs, fertile and water saturated areas on the banks are formed. Theses areas are utilized by small farmers to grow different types of vegetables and fruits. The same simple technologies used in flood systems are also used here.

Table 10.3 Identified Best Practices on Public/Private Managed Irrigation in Sudan

Best Practice		Description
1	Long furrow	Long furrow irrigation was first largely introduced to the Sudan in Rahad Agricultural Project in eastern Sudan in the mid 1970's, but was abolished for many reasons. Today long furrows are only largely used in Kenana Sugar fields in the White Nile state. Long furrows that reach 2.75 km are established after the land is prepared and laser levelled. Siphons are used to deliver water from the canals to the furrows.
2	Gated pipes	The gated pipes system was introduced lately and adopted largely in Kenana sugar fields in the White Nile state. This system helped in reducing irrigation water delivery losses and also reduced time and cost of irrigation of sugar fields.
3	Stationary sprinkler systems	These systems are used in limited areas of vegetable production and commonly used in landscaping to irrigate turfs and ornamental plots in Khartoum state.
4	Centre pivot sprinkler irrigation	This is practiced in Khartoum, Nile, and Northern states. It is mainly used by modern investment companies to cultivate alfalfa for export and other field crops such as wheat. Source of water for these systems is either from the Nile or from ground aquifers.
5	Linear sprinkler irrigation	Used in Khartoum and Nile states by modern investment companies. These systems, same as centre pivot systems, are used to cultivate wheat, alfalfa, and vegetables.
6	Drip irrigation systems	Largely used in landscaping and to irrigate house gardens. Drip irrigation is used in orchards to irrigate trees and also used in green houses to produce vegetables in Khartoum and Gezira states

10.5 Potential for Community Based (Small Scale) Irrigation

There is considerable scope for increasing productivity on all schemes. Traditional ownership and land use practices are inhibiting crop production on both modern and traditional schemes. In spite of many efforts to improve farmer responsibility, involvement and management, past efforts have not produced the anticipated results. Farmers Unions have proved very strong and conservative and many of the established norms for formation and involvement of WUAs have proved unsuitable to these schemes that have many years of operation under traditional rules, and where government have always met the MOM charges.

Lessons on irrigation systems and land management from all areas can be applied to similar agro ecological zones in all of the member countries, particularly relating to sediment exclusion and implementation of operation and maintenance.

10.6 Best Practice Sites

A number of best practices in CBSSI are available in most states. Recognition of the diversity of practices and the distribution of these sites, led to the selection of locations based on discussions with those experienced with irrigation development and management. This led to wider dissemination of ideas, and exchange of experiences which have been identified in (Table 10.4). In Table 10.5, the best practise in Public/Private Managed Irrigation has been shown.

Table 10.4 CBSSI Best Practices

Best practice Site		Location	Technology level
1	Surface irrigation	a. Gezira Scheme	Traditional
		b. New halfa Scheme	
		c. Rahad project	
		d. Suki project	
2	Basin irrigation	a. Wad Hamid, Nile State	Traditional
3	Spate irrigation	a. Gash	Traditional
		b. Tokar	
		c. Abu Habil	
4	Flood on river banks	a. Nile state	Traditional
		b. Khartoum State	
5	Flood on seasonal river banks	a. Atbara River	
6	Flooded islands	a. North State · Traditional	Traditional
7	Seasonal streams water courses	a. Rahad	Traditional
		b. Dindir	
8	Banks of Dams lakes	a. Rosereis	Traditional
		b. Sennar	
		c. Jabel Aulia	

Table 10.5 Best practices in Public/Private Managed Irrigation

Best practice Site		Location	Technology level
1	Long furrow	Kenana	Modern
2	Gated pipes	Kenana	Modern
3	Stationary sprinkler systems	Khartoum State	Modern
4	Centre pivot sprinkler irrigation	a. Nile state	Modern
		b. North state	
5	Lateral sprinkler irrigation	a. Khartoum State	Modern
		b. Nile state	
6	Drip irrigation systems	a. West Omdurman	Modern
		b. African/Malaysian	

The full description and ranking of BP sites have not yet been provided. However, some reasons for the selection of the sites are given below.

The Gezira Scheme is considered as the largest irrigation project under one management in the world, and it is this uniqueness that qualified it to be the site for best practices in public/ community managed irrigation systems. Located between the Blue and White Nile, it was established in 1925 when the Sennar Dam across the Blue Nile was completed. Between 1959-63 the original Gezira

Scheme was extended to include the Managil area, and the combined Gezira/Managil Scheme now covers an area of about 2.1 million feddan (about 882,000 ha), which is all under gravity irrigation. Estimates of the total potential cultivable area within the Nile Basin in Sudan vary from 4-5 million feddan. Hence, the Gezira Scheme represents about 50% of all irrigation schemes drawing water from the Nile system. Additionally, the scheme uses about 35% of Sudan's current allocation of Nile water. Studies reveal that about 55% of the Gezira Scheme is the property of the central government, with the remainder still owned by previous landholders, and with whom the central government has a long term rental agreement. Designed for a 75% cropping intensity, the achieved cropping intensity is usually no more than 50% which is very low by international standards.

The management of the Gezira Scheme in respect to irrigation water has always been divided between the Ministry of Irrigation and Water Resources (MOIWR) and Sudan Gezira Board (SGB). MOIWR is responsible for supply and delivery of water to the minor canals. In 1995, MOIWR established the Irrigation Water Corporation (IWC), a financially independent parastatal, to operate and maintain the irrigation system in the GS and other large central government-owned scheme. In practice, the tenants are involved in the operation and maintenance of the smallest field canals (Abu Sittas), including the control of the operation of the larger tertiary canals (Abu xx). The maintenance of Abu xx canals is carried out by SGB at the tenant's expense. The Gezira Scheme is now passing through a transformation process in which farmers are starting to manage the lower level system (minors and field canals) through the Water User Associations, established by the 2005 Gezira Act. Current water management in the Gezira Scheme is substantially different from the original design, which was used satisfactorily prior to the 1960's. The two-fold expansion of the irrigation area and successive crop intensification in the mid-1960's following completion of Managil extension required additional quantities of water to be diverted and distributed. Accordingly, the volume of water released to the system at Sennar increased by more than three-fold from 2,000 million cubic meters in 1957-58, to 7,100 million cubic meters in 1997-98.

Kenana Sugar Estate was selected to represent best practice site for private irrigation in the Sudan, as it is one of the best examples of the adaptation of new technologies, especially in irrigation and one of the best managed agricultural projects. The scheme has high efficiency of management and the modern technology adoption in seed bed preparation, laser levelling and modern irrigation systems such as gated pipes and long furrow systems. Kenana Sugar Estate (lat. 13ºN 3, long. 30º East) is located in the Central Clay Plain of Sudan, about 300 km south of Khartoum near the town of Rabak (White Nile State) on the eastern bank of the White Nile. The total area of the project is 70,000 ha, with the cultivated area amounting to 45,000 ha. Six pumps are connected in series along the main canal to lift irrigation water to 46 m above the level of the White Nile. The first two pump stations were designed to pump $42m^3/s$. The main canal is branched into the primary canal to divert irrigation water to the field canal via off take pipes. Each field canal is designed to irrigate one field (40-90 ha), which is split into two sectors, each sector consisting of 60 furrows with 1.55 m spacing. Furrows run perpendicular to contour lines with lengths ranging from 300 to 2750 m.

Irrigation practice in Kenana was subjected to many changes. In 1981, the water indenting was based on fixed days per cycle, and different sizes of siphons were used in the same field to maintain the cycle regardless of the field gradient of furrow length. An irrigation system based on evapotranspiration 910 mm/day) was introduced in 1983. In 1987, an indenting system of irrigation based on the number of operating pumps was adapted. Recently, the Estate field was divided into three categories (A, B, and C) based on steepness and furrow length. These categories received water every 12, 10, and 7 days respectively. In 2002, the open channel furrow irrigation system was gradually changed to the close system of gated pipes. Today, about 75% of the planted area is using the closed irrigation system.

11 TANZANIA

11.1 Overview

Agriculture plays a significant role in the livelihoods of households in the Nile Basin, contributing greatly to economic growth and Gross Domestic Product (GDP). It accounts for over half of the GDP and export earnings, with over 80% of the population living in rural areas and depending on agriculture for their livelihoods. The sector is affected by inadequacy, seasonality, and unreliability of rainfall as well as periodic droughts. Improvement of yield and reliability of agricultural production on irrigation schemes is thus a high priority of the government, together with improved water availability and land productivity, through the promotion of CBSSI practices and technologies in the country.

Irrigation development involves around 1,428 irrigation schemes of which 1,328 are smallholder, 85 private and 15 government-managed schemes[51]. 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. The Agricultural Sector Development Strategy (ASDS) aims to support an improvement in agriculture to reduce fluctuations in production through improved irrigation. Combined with this, the growing pressure to reduce the amount of water allocated for agricultural production due to increasing demands from other sectors, has led to an initiative to produce more crop per given volume of water, including the realisation of the need to rehabilitate and upgrade many existing irrigation schemes in the country.

11.2 Agro-Ecological Zones (AEZ) of Tanzania

Tanzania has about 89 million ha of land suitable for agricultural production, including 60 million ha of rangelands suitable for livestock grazing. The country is divided into seven agro-ecological zones (Table 11.1), which are classified based on altitude, rainfall pattern, dependable growing seasons, average water holding capacity of the soils and physiographic features.

Table 11.1 Main Agro-Ecological Zones of Tanzania

Zone		Altitude metres (amsl)	Rainfall pattern	Dependable growing season (months)	Physiographic
1	Central plateau	800 to 1800	Unimodal & unreliable	2 to 6	Composed of flat plains, undulating plains, plateau and some hills
2	Eastern plateau and mountain blocks	200 to 2000	Predominantly unimodal	From < 2 to 7	Many physiographic types, ranging from flat areas, undulating and rolling plains, hilly mountain, plateau to mountain blocks
3	Inland sedimentary plateau, Ufipa plateau and western highlands	200 to 2300	Unimodal	3 to 9	Composed of undulating plateau, strongly dissected hills, dissected hilly plateau and undulating rolling plains.
4	Northern rift valley and volcanic high lands	900 to 2500	Unimodal	< 2 to 9.5	Ranges from flat to undulating plains, hilly plateau to volcanic mountains
5	Southern highlands	1200 to 2700	Unimodal	5 to 10	Composed of flat to undulating rolling plains and plateau, hilly areas and mountains
6	Coastal	< 100 to 500	Bimodal and Unimodal	3 to 10	Combination of coastal lowlands, uplands, undulating and rolling plains
7	Rukwa-Ruaha rift zone	800 to 1400	Unimodal	3 to 9	Composed of flat, rocky and complex terrain

[51] NIMP, 2002

11.3 Community Based (Small Scale) Irrigation Sites

Traditional irrigation has been practiced in Tanzania since 1700, and more widely in a number of regions[52] since 1890. Many irrigation schemes have deteriorated and become inadequate due to population increase, wear and tear, catchment degradation and a breakdown in traditional informal user organisations. Similarly, many of the community based (small scale) irrigation sites are managed by informal or formal Water User Associations (WUAs), which are responsible for management, operation and maintenance (MOM), including water scheduling and planning. The main irrigated crops are paddy and maize, which accounted for about 48% and 31% of the irrigated areas in 2002 respectively. Other irrigated crops account for 44% of irrigated areas, with an average cropping intensity of 123%. Recently, government has been implementing irrigation schemes in arid and semi arid lands (ASAL) based on traditional rainwater harvesting technologies together with storage dams[53]. 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.

Tanzania has large areas with medium rainfall, gently undulating topography and a well distributed population that are suited to CBSSI. There are good examples of tried and improved practices. Good CBSSI practices have enabled farmers to produce not only their own food crop needs, but to increase their assets. As a result, many farmers are able to meet school fees of their children, provide better housing for their family, and to better support other members of their extended families. Surface irrigation is most widely practiced and improvements in water use and application efficiency on these schemes offer good scope.

11.4 Identified Practices

Almost all schemes are gravity-fed (99%) from surface sources[54] 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[55] with drip rarely used except on pilot schemes, run by government or in small-scale water harvesting[56].

[52] Arusha, Iringa, Tanga, Mwanza, Shinyanga, Kilimanjaro, Mbeya Morogoro and Ruvuma
[53] Smallholder Irrigation Development Project for Marginal Areas and Participatory Irrigation Development Project.
[54] Groundwater is utilized on only 0.2% of all irrigated areas.
[55] Private irrigation schemes produce cash crops such as tea, coffee, cashew and sugarcane.
[56] 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.

Table 11.2 CBSSI Practices in Tanzania

	Irrigation practices	CRITERIA						Total	Rank	Example of scheme
		Water use efficiency	O&M	Technical requirement	Labour requirement	Environmental impact	Possibility of out-scaling			
1	Gravity, open channel (semi-lined), level basin	10	10	10	2	2	20	54	1	Mombo
2	Pumped, piped, lateral drip	20	2	1	10	10	10	53	2	Kibena Tea
3	Gravity, open channel (lined), level basin	10	10	10	5	2	15	52	3	Lower Moshi
4	Gravity, open channel (unlined), level basin	5	10	10	2	2	20	49	4	Lekitatu
5	Pumped, piped, movable sprinkler	20	2	1	5	10	10	48	5	Kilombero sugar 1
6	Pumped, open channel/ piped, pivot	15	2	1	10	5	10	43	6	Kilombero sugar 2
7	Pumped, open channel/ piped, movable sprinkler	15	2	1	5	5	10	38	7	Kibena tea
8	Pumped, open channel (unlined), level basin	5	5	5	2	2	15	34	8	Dakawa

Eight CBSSI irrigation practices commonly used in Tanzania were ranked using a six point criteria: Water use efficiency (very high=20, high=15, med=10, low=5), O&M (high =2, medium=5, low =10), Technical requirement (complex=1, some how complex=5, simple=10), Labour requirement (high =2, medium=5, low =10), Environmental impact (high =2, medium=5, low =10), Possibility of out-scaling (high =20, medium=15, low =10). The results are shown in Table 11.2 that also lists those practices that are found to exist in the sites of Best Practice.

11.5 Potential for Community Based (Small Scale) Irrigation

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 11.3). NIMP projected an increase in irrigated area from 264,000 ha (June 2006), to about 405,400 ha by 2017 or 18% of the high potential area. The need to improve irrigation infrastructure, production practices, water management and adoption of new technologies was also emphasized[57].

Table 11.3 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**

There are good opportunities for the improvement and upscaling of the CBSSI practices. The main aim must be to encourage those techniques that are simple in design and easy to implement, with the resources available to the communities. Strong WUAs are essential to good management and productivity, and those schemes that have provided the best results have combined WUA improvement and support, together with scheme rehabilitation and the river basin management approach. Tanzania has an excellent base for the improvement of the irrigation systems in the country. The country's completed Irrigation Master Plan lists all the sites which have been identified, and for which basic information and data are available. Initial assistance for the improvement of the schemes was hampered by the narrow approach adopted by donors in the interpretation of SWAP support. This

[57] Government has launched an irrigation research programme to conduct experimental trials and field demonstrations to farmers throughout the country.

approach failed to understand the types of irrigation, and the need to adopt national rather than Distract planning approaches for most of the existing schemes. This has since been corrected.

The pattern of availability of water for irrigation and potential is important as this is not uniform across the country. Studies reveal that some areas require a water harvesting approach with appropriate technologies, such as the use of Charco dams. Good estimation of available runoff water from a given catchment / sub-catchment is essential, and prevents wastage of resources and farmers efforts. Although many relevant guidelines and manuals have been prepared (mostly by the Department of Irrigation and Technical Services (DITS) of MIWR[58] on an individual project basis (Table 11.4), detailed assessment of runoff for small catchments with limited records has not be well covered. Additional guidelines and manuals for these aspects and others thus need to be developed, and some are already under preparation by DITS.

Table 11.4 Relevant Guidelines and Manuals for Tanzania

Project	Period	Title	Description
ISID	1991 - 1994	Project Planning manual	The manual consisting of eleven sections covering all items necessary for irrigation scheme planning, from survey to project evaluation. The manual was prepared to provide guidelines on investigation and studies necessary for feasibility study. Unfortunately, the manual has been hardly utilized by all concerned personnel.
ASDP	1996 -	Technical Manual for Planning and Design of Irrigation Systems, Construction Manual for Irrigation Works, Technical Manual for Operation & Maintenance of Irrigation Systems	The manual provides technical and procedural guidance to all personnel involved in planning, designing, implementation and O & M of irrigation system. However, it is still a draft, and has not been finalized.
RBMSIIP	1999 - 2000	Irrigation Design Manual	The manual consists of two volumes: guidelines and drawings. It is a well-organized outcome. The guidelines might be useful for experts with some experience in irrigation design works, but troublesome for those with less experience (such as District staff). Furthermore, the guidelines do not deal with methodology for participatory design, which is now a fundamental requirement (JICA & MAFC 2007).
PIDP	2000 - 2001	Rainwater Harvesting Design Manual for Irrigated Agriculture in Marginal Areas	A design manual consisting of eleven chapters. Contains information on WH but has been developed from earlier international references, and also parts of the manual present design methods for conventional irrigation system with insufficient adaptation for water harvesting scheme design.
ASPS-IC	2001 -	Irrigation Water Management Field Handbook for Extension Staff	The handbook aims to provide extension field personnel with information on irrigation water management as a quick reference manual. The handbook consists of ten chapters covering technical issues as well as formation of irrigators' association and environmental issues in irrigation systems.
		Project planning manual	Consists of eleven sections to provide guidelines on investigation and studies necessary for feasibility study. The manual focuses on medium to large scale schemes (modern irrigation schemes).
	2007	Guidelines for Irrigation Scheme Formulation for District Agricultural Development Plan	The guidelines focus on district-manageable small-scaled irrigation schemes (gravity& pump irrigation schemes or water harvesting scheme). The objective of these guidelines is to provide the district staff with a procedure for irrigation scheme formulation in the preparation of DADP.
Note: 1. The documents have formed the basis for additional guidelines that have been used by projects such as RBMSIIP, PIDP and the National irrigation Master Plan Studies. 2. Other guidelines have subsequently been prepared by the Master Plan Team (District Level Planning) and PIDP.			

Functional community groups are a prerequisite for successful CBSSI with village and District governments playing a pivotal role. The presence of a working/profitable CBSSI system in one area will attract interest from other similar schemes in the same District. Many CBSSI systems depend on a shared water source. In the past, work conducted under the River Basin Management and Smallholder Irrigation Improvement Project (RBMSIIP) project, funded by government and the

[58] Prior to 2008, Irrigation was included under the Ministry of Agriculture.

World Bank, has provided good results and appropriate mechanisms for dealing with water shortages, and improving the sustainability of the organisations managing the Basin. The institutional arrangements are most important in these cases, where more than one scheme is dependent on water from the same source/river. The Basin offices established for this purpose has wide applications throughout the Basin in the context of overall national framework of water management, and for overcoming conflicts and sabotage of otherwise good initiatives.

The establishment of market linkages in the successful CBSSI schemes has led to farmers changing some or all of their crops from traditional to high value crops. The freedom to make this change under current government support has been very effective, and has led to the wider adaptation of improved CBSSI schemes. It is worthwhile to mention that undue restrictive government policies on crops to be grown must therefore be avoided. Basin wide CBSSI experiences and best practices although documented, must be improved so that benchmarking can take place and in-country experiences publicised wider. This must also include full details of the sites and circumstances under which it has been developed and improved. The interaction of local communities and support provided from the Districts and central government can be decisive in improving the success of CBSSI, and how the community adapts to changing circumstances.

High implementation costs will reduce wider adaptation of scheme improvements and therefore the approach of selective rehabilitation and upgrading must be adopted. Community supported improvements and involvement will encourage government and donors to support the initiatives more readily.

11.6 Best Practice Sites

The locations of CBSSI Best Practices are given in Figure 11.1. Details of the results of ranking in Table 11.4. The shortlist of possible BP were determined from a long list with those sites, included meeting a variety of selected criteria.

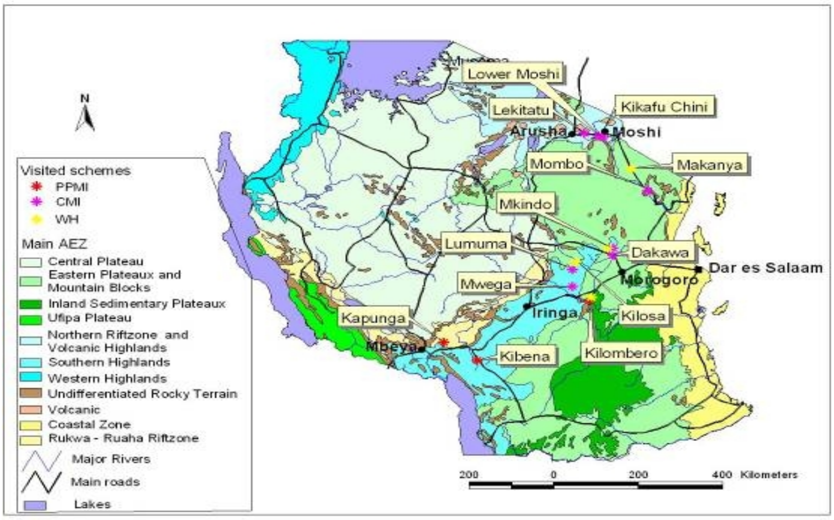


Figure 11.1 Location of CBSSI Best Practice Sites in Tanzania

Lekitatu is ranked highly due to the fact that the scheme has a strong farmer's organization called UWAMALE (Umoja wa Wamwagiliaji Maji Lekitatu). The association has three strong committees: O & M, environment and agriculture, and finance and planning. In addition, since 1996, farmers have been attending various trainings, particularly from KATC, TPRI and Arumeru District Council that have improved their agricultural production. The training includes water management, use of simple farm machinery, cooperatives, agribusiness, marketing, rice agronomy and handling and use of agro-chemicals, including fertilizer, herbicides and pesticides. Furthermore, farmers and their extension officer and irrigation technician have attended various in-country workshops and seminars and sometimes abroad (e.g. Ethiopia and Zimbabwe).

Table 11.5 Ranking of BP sites for CBSSI practices

Site	Ranking Criteria							Total points
	Technical factors (15)	Economic Factors (18 points)	Possibility of Environmental status factor (12 points)	Ease of implementation (5 points)	Social factors (24 points)	Regional condition (20)	Water use efficiency (6)	
Lekitatu	9	14	9	5	23	16	2	79
Mwega	9	15	8	5	21	14	3	75
Mombo	9	13	8	5	23	10	3	71
Kikafu Chini	10	13	6	3	23	14	0	69
Mkindo	7	13	6	3	21	16	0	66
Lumuma	11	14	8	1	19	8	0	61
Lower Moshi	4	17	6	5	12	11	5	60
Dakawa Rice Farm	7	8	3	3	21	12	0	54

Note: Table 11.2 gives practices. The above table gives the sites on which they are found.

Through the adaptation of best Practices/technologies under RBMSIIP, overall efficiency of water use greatly improved from below an estimated 15% to an average of 30% after scheme improvement. This resulted from physical improvements, to diversion and control structures and conveyance and distribution systems, and training of farmers in irrigation water management. This approach has wide application both in Tanzania and elsewhere in the Basin where demand for water from other sectors of the economy is putting pressure on schemes to reduce water use.

Where more than one village is dependent on water from the same source/ river, it is important to have arrangements (upstream and down stream institutions) for sharing the water resource. In the absence of such arrangements, conflicts and sabotage of otherwise good initiatives can not be avoided. Consultation with Basin offices is necessary, in order to work within the overall national frame work of water management in the relevant Basin.

Community managed irrigation schemes are usually traditional or improved systems. In Tanzania, improved irrigation schemes are a product of Government and NGO intervention on conveyance and intakes of traditional systems, to enable better control of abstraction and to reduce water lose. The command area and hence the number of people benefiting from individual schemes has increased through such improvements. The targeting of the existing traditional irrigation schemes, is based on the fact that these have survived and performed relatively well for a long period. Such schemes tend to have coherent and well organised WUGs/ WUAs. This is the key to sustainability, and thus, such schemes may not perform well in areas/ locations where elaborate organisation is not in place. The government through District Councils is training members of these groups in management, finance, use of agricultural machinery, control of pests and diseases and running of cooperative societies[59]. Most of these WUGs have become fully registered cooperatives. This has assisted farmers in joint: bargaining, marketing, procurement of inputs, and acquisition of credit.

Construction of expensive irrigation structures is dependent on the perceived security of the land tenure systems. Farmers growing crops on hired land are reluctant to invest, for fear of losing land to

[59] Initially, cooperatives were adopted as the enabling legislative environment existed under coop law. Since then, irrigators organisations have had the opportunity the continue to register under the same law or under new WUA legislation. Government is recommending re-registration under the WUA law.

the owner as soon as such improvements have been undertaken. CBSSI schemes require availability of large pieces of land. Hence, secure land tenure is a prerequisite for the success of CBSSI. Additionally, the availability of reliable data is crucial for planning of CBSSI schemes. The most important parameters include rainfall, soil texture, soil depth, topography, drainage conditions, land use and vegetation covers. Promotion and up scaling of irrigation and water management technologies depends on the availability of long term weather data. Thus, the absence of data can be a hindrance to proper planning and can limit chances of the success of a scheme.

12 UGANDA

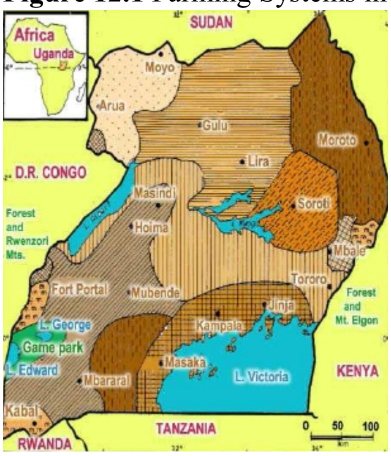
12.1 Overview

Uganda covers an area of 241,000 km^2 of which 18% is occupied by water or swamps. Most of the country lies in the Nile Basin, and more than two-thirds has elevations from 1,000 to 2,500 m. It has good rainfall distribution patterns, varying from 750 mm/an in the Northeast Karamaja pastoral areas to 1,500 mm/an on the shores of Lake Victoria. This includes areas around the Mt. Elgon highlands in the East, the Ruwenzori Mountains in the Southwest, Masindi in the West and Gulu in the North. In spite of this, water remains essential in rural areas, especially in the relatively dry north-eastern and north-western "cattle corridor" due to its large human and livestock population. In these areas, irrigation is essential for crop production needs. Irrigation is a relatively new concept in the area, 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 was 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 levels, with most of this located on the fringes of swamps. Nowadays, rainfall has become less reliable, with supplementary irrigation needed in the rainy season at times, and much of this has been developed by smallholders without planning, and with little or no technical assistance.

Agriculture dominates the country's economy and accounts for 43% of GDP, 85% of export earnings, 80% of employment and provides most raw materials for the agro-based industrial sector. Twenty two million people live in rural areas and depend on agriculture for their livelihoods, 75% of these (3 million) include smallholder farmers with average landholdings of 2.2 ha. The hand-hoe is the predominant technology for cultivation of mainly food crops (71% of agricultural GDP), with livestock products (17%), and export crops and fisheries constituting (9%). Only a third of the food crops produced are marketed compared with two thirds of livestock produced.

12.2 Agro-Ecological Zones (AEZ) of Uganda

Figure 12.1 Farming Systems in Uganda (left, below)



Uganda's temperatures show little variation throughout the year, with maximum ranges of 25o - 31ºC for most areas. Rainfall distribution has generally been categorised as:-

- High: >1750 mm pa - 4% of the land area;
- Moderate: 1000 - 1750 mm pa 70% of the land area;
- Low: < 1000 mm pa 26% of the land area;

In Southern Uganda, bimodal rainfall distribution occurs allowing two crops annually and adequate livestock grazing throughout the year. Around Lake Victoria, rainfall is well distributed, ranging from 1200 to 1500 mm per annum. Towards the North, the two rainy seasons gradually merge into one, with dry periods at the year end becoming longer and annual rainfall decreasing to 900-1300 mm per annum. This restricts the range of crops that can be grown and conditions favour extensive livestock production.

Farming systems are divided into seven broad agro-ecological zones (Figure 12.1 and Table 12.1) based on soils, topography, rainfall and major crops grown. The main feature is mixed enterprises with food crops being the dominant activity supplemented by a few export crops, such as coffee, cotton, tea and tobacco, and livestock. In the pastoral farming systems that exist in the northeast and a part of the west, livestock production constitutes the primary activity supplemented by the production of some food crops.

Table 12.1 Agro-ecological zones of Uganda.

Farming system AEZ		Description	Districts	WH Practice
1	**Banana/ Coffee System**	- Rainfall is evenly distributed (1 000 - 1 500 mm) - Soils of medium to high productivity; - Areas cultivated per capita are small, under one hectare; - Banana, coffee are the main cash root crops, maize, sweet potatoes secondary food to bananas; - Livestock is generally not integrated into the system, but dairy cattle are gaining prominence; - Vegetation is mainly forest-savannah mosaic.	Bundibugyo, parts of Hoima, Kabarole, Mbarara, Bushenyi, Mubende, Luweero, Mukono, Masaka, Iganga, Jinja, Kalangala, Mpigi and Kampala	Water shortage for both agriculture and domestic use not acute. Relatively low practice of roof WH, valley tanks/ dams, supplemental irrigation.
2	**Banana/Millet/ Cotton System**	- Rainfall is less stable than for the banana-coffee system; - Greater reliance on annual food crops (millet, sorghum and maize); - In the drier areas, livestock is main activity.; - Vegetation is moist savannah with moderate biomass production.	Kamuli, Pallisa, Tororo, parts of Masindi and Luweero	Water shortage is acute only in long dry season WH used more widely with roof WH, valley tanks/ dams, supplemental irrigation.
3	**Montane System**	- Elevations between 1500 - 1750 m above sea level; -High and effective rainfall and d cover; - Banana, sweet potatoes, cassava and Irish potatoes. Arabica coffee, wheat and barley above 1600 m; - High population intensities and intensive agriculture, small holdings of about 1.5 ha. - Long dry season (June – August) more pronounced than in AEZ 1.	Kabale, Kisoro, parts of Rukungiri, Bushenyi, Kasese, Kabarole, Bundibugyo, Mbarara, Mbale and Kapchorwa	Water shortage is acute only in long dry season. In situ WH, terraces, contour bunds, conservation structures, used more widely due to steep slopes.
4	**Teso systems**	- Bimodal rainfall. Dry season longer from December to March; - Soils; sandy-loams of medium to low fertility; - Vegetation is moist & grass savannas; short grassland ideal for grazing; - Millet, maize, sorghum; groundnuts, simsim (*Sesamum indicum*), sunflower, cotton grown; - Mixed agriculture (crops & and livestock) with cultivation by oxen. - Average farm size is about 3 ha.	Soroti, Kumi, Kaberamaido	Water shortage is acute in long dry season. Paddy rice, valley tank/dam for livestock watering, supplemental irrigation
5	**Northern System**	- Rainfall; less pronouncedly bimodal with about 1200 mm annually. In far north/ north-east rainfall is uni modal and too low (<800 mm)/erratic for satisfactory crop production; - The dry season is so severe that drought tolerant annuals are cultivated, Only one growing season; - Finger millet (*Eleusine coracana)*, simsim, cassava, sorghum, tobacco and cotton are grown; - Grassland is short and communal grazing abounds. well-known for pastoral system & semi nomadic cattle herding; - Vegetation; short grassland	Gulu, Lira, Apac, Kitgum	Water shortage is acute in long dry season. WH not widely practiced.
6	**Pastoral System**	- Annual rainfall is low (less than 1000 mm). - Vegetation; short grassland where pastoralism prevails with nomadic extensive grazing. - Mixed herds are common but with no sound information on cattle: small ruminant ratios for optimum grassland use.	Kotido, Moroto, parts of Mbarara, Ntungamo, Masaka, Ntungamo, Masaka and Rakai	Water shortage acute in long dry season. Pastoral area and thus WH for both animals and domestic use widely practiced - Valley dams/ tanks, roof WH, Supplemented irrigation.
7	**West Nile System**	- Rainfall pattern resembles northern system with more rain at higher altitudes. Long dry season (December – March) more pronounced; - Mixed cropping is common with a wide variety of crops. - Vegetation is moist grassland. - Livestock activities limited by the presence of tsetse fly; - Finger millet (*Eleusine coracana)*, simsim, cassava, sorghum tobacco and cotton are grown.	Moyo, Arua and Nebbi	Water shortage is acute in long dry season. WH not widely practiced.

12.3 Community Based (Small Scale) Irrigation Sites

Formal irrigation developments commenced in the 1960s, and currently around 56,000 ha of land is irrigated. In 1998, the area equipped for irrigation was 5,580 ha, most of which is located in the southeast part of the country in the districts between Lake Victoria and Lake Kyoga. The actual irrigated land covers 2,330 ha. Surface irrigation is the main irrigation technique, while 230 ha are equipped for sprinkler irrigation, and localized irrigation is practiced at a pilot-scale at three sites.

On CBSSI schemes, the technology used is basic and approaches are sometimes inappropriate. Most smallholder schemes grow rice and vegetables, with the larger commercial estates cultivating rice and sugarcane. The progress with formal irrigation has been very slow and with limited success. One reason is the top-down approach adopted in most schemes. Farmer-based (CBSSI) schemes of Mubuku, Doho and Agoro have been considerably more successful. Informal small-scale irrigation practised mostly in the southeast of the country has been increasing, especially for rice, vegetable and fruit production with the increased area of rice production resulting from the adaptation of technology from the Kibimba Rice Scheme.

12.4 Identified Practices

Most irrigation developments use surface methods, although the more recently drip and micro sprinkler have been used in green house irrigated flower farms that started in 1990s. In Table 12.2, irrigation technologies and practices that are found in the country are listed. This includes both public and private sector developments. The most suitable technologies are those that are afforded by the poorer beneficiaries involving surface irrigation and simple techniques, as experience with irrigation in the country is rather recent. The interventions undertaken must also relate to the capacity of the District technical support for sustainability.

Table 12.2 List of irrigation technologies/practices found in Uganda

Irrigation Technology/ practice	Crops	Example Location of practice	Attributes					
			Benefit	Maintenance & Management	Cost	Spare parts availability	Technical support	Water use efficiency
Furrow	Vegetables, cotton, maize	Mubuku scheme	Increased yield	Poor	Low	Local	District MAAIF NARO	Low
Basin	Rice	Pallisa Tororo Kimbimba Doho	Increased yield	Average	Low	Local	District MAAIF NARO	Low
Sprinkler	Fruits, vegetables, flowers	Kiige, Ongom	Increased yield	Poor	High	Kampala	District MAAIF NARO	High
Drip	Flowers	Kampala, Entebbe	Increased yield	Poor	High	Kampala	District MAAIF NARO	High
Treadle pump	vegetables	Rural, peri –urban (Jinja)	Increased yield	Poor	Low ($ 100-150)	Kampala	District MAAIF NARO	Average
Watering can/bucket	Vegetables, nurseries	Urban, rural areas	Increased yield (small production)	High	Low	Town Kampala	District MAAIF NARO	Average
Gravity flow/flooding	Various	Where elevation difference exists, rural areas	Increased yield	Average	Low	Local	District MAAIF NARO	Low

12.5 Potential for Community Based (Small Scale) Irrigation

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).

The need for supplementary irrigation is becoming increasingly important, due to unreliable rainfall and the effect of global warming. Farmers can increase their current yields by 50% or 100%, if supplemental irrigation was used. Most farmers are either not aware of the benefit of irrigated agriculture or they consider it to be too expensive. Paddy rice is the most commonly practiced irrigation system in Uganda in the wetlands of the east. The drier areas such as the pastoral AEZ and the western rift valley also practice irrigation to some extent. The best irrigation practice is the paddy rice and gravity. Although these practices are not so good in relation to some criteria such as water use efficiency, they have been found to excel due to high profitability, affordability and adoptability by the communities.

More information and guidelines on CBSSI are needed for both communities and technical practitioners. Although some material is available, it is aimed more at engineering aspects such as the water supply design and construction of medium-sized communal water reservoirs in dry belts. Some manuals on smallholder paddy rice cultivation in seasonal wetlands and on wetland edge gardening exist, as well as unpublished training modules on irrigation and water harvesting from the Department of Agricultural Engineering, Makerere University. The development of National guidelines for irrigation water harvesting is very important. Applied research for the demonstration of the benefits of irrigated agriculture and for improvement of water use efficiency for the gravity systems is vital for increased and sustainable adaptation of irrigation technology. Likewise, the importance of the research and demonstration of efficient and sustainable wetland resources utilisation for agricultural production should be equally emphasised.

12.6 Best Practice Sites

The best sites should have high water use efficiency, be managed effectively, be properly maintained, be profitable, benefit the farmers and community and have good environment management (water borne diseases, chemicals). The site may not necessarily have all the above mentioned attributes to be considered a best practice site, but a few good attributes will give it a higher rating than others.

Table 12.3 Identified BP Sites in Uganda

Irrigation Site, ownership	District	Crops	Choice factors					
			Environment management	Maintenance management	Yield increase	Management structure	Market availability	Water use efficiency
Iganga Paddy rice growers communities	Iganga	Rice	average	average	High	average	Good	Low
Pallisa Paddy rice growers communities	Pallisa	Rice	average	average	High	average	Good	Low
Tororo Paddy rice growers communities	Tororo	Rice	average	average	High	average	Good	Low
Mr.Sembusi Richard Bulenge Village Buwunga sub county Private/community	Masaka	Coffee, banana, pineapple, coffee nursery, fish pond	Good	Good	High 2 ton/acre	Average	Good	Low
Mr. Mpinde Livingstone Katolerwa village Kibinge sub county. Private	Masaka	Coffee, coffee nursery	Good	Good	High: 19 bags increased to 34 bags/ac.	Average	Good	Low

In Table 12.3, the identified CBSSI BP best practices are listed with management and water use being the most problematical on each site. The selection of the best practices and sites was accomplished using the ranking system developed, and confirmation of the ranking results through field visits. The field visits did confirm that the practices/sites selected through the process of ranking were indeed best sites. Some of them did not fulfil all the criteria for best sites, but have outstanding attributes above other practices/sites in the country. The final lists are presented below in Table 12.4. Good practices are also found on the three rice schemes and although these are not small scale, there are lessons and experiences that can be utilised elsewhere. The greatest constraint on these schemes is the lack of secure land tenure, and this is a responsibility of the government l. unless this issue is addressed, the schemes and the considerable number of out-growers will continue to work individually, and inhibit production and water use efficiency. The opportunities and limitations of best practices/technologies for replication and scaling up are listed in Table 12.5.

Table 12.4 Ranking of best practice site for CBSSI in Uganda

			Ranking of best Sites				
Criteria		Score	**Mr.Sembusi Richard Bulenge Village, Masaka**	**Mr. Mpinde Livingstone Katolerwa village**	**Palisa Paddy rice growers communities**	**Iganga Paddy rice growers communities**	**Tororo Paddy rice growers communities**
Water use efficiency,%	<30	1			1	1	1
	30- 40	2	2	2			
	40- 60	3					
	60-80	4					
	>80	5					
Yield increase/profits %	<40	1					
	40- 60	2					
	60- 80	3			3	3	3
	80-100	4					
	>100	5	5	5			
Number community members adopted technology	<3	1		1			
	3 to 6	2	2				
	6 to 10	3					
	10 to 20	4					
	>20	5			5	5	5
Water users association	no/very weak	1		1	1	1	1
	weak	3					
	strong	5	5				
Level of maintenance	poor	1					
	average	3			3	3	3
	good	5	5	5			
Envronment management	poor	1					
	average	3			3	3	3
	good	5	5	5			
Market for product	poor	1					
	seasonal	3					
	readily availabbl	5	5	5	5	5	5
		Total	29	24	21	21	21
		Rank	1	2	3	3	3

Table 12.5 Opportunities and Limitations for Replication and Scaling of Best Practices

Type of Technology	Best Practice Site/ Technology	Opportunities	Potential areas/AEZ for replication	Limitations
Community Small scale irrigation	Mr.Sembusi Richard's gravity irrigation system	• Cheap to construct and operate • Available streams/rivers in most parts of country	• Mountainous areas • In all AEZ	• Requires difference in elevation between field and water source • Permanent source of water
Public Private Large scale irrigation	Doho rice scheme	• Plenty of wet lands/stream, especially in the eastern part of Uganda • Available technology	• Where there are wetlands	• Requires good water control especially during floods
	Tilda (Kimbimba) rice scheme	• Plenty of wet lands/stream, especially in the eastern part of Uganda • Available technology	• Where there are wetlands	• Requires good water control especially during floods