Efficient Water Use for Agricultural Production (EWUAP) Project

BEST PRACTICES FOR WATER HARVESTING AND IRRIGATION

Kenya

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ABBREVIATIONS AND ACRONYMS

ICRAF	International Centre for Research in Agro-forestry
EWUAP	Efficient Water Use for Agricultural Production
LBDA	Lake Basin Development Authority
MOA	Ministry of Agriculture
NIB	National Irrigation Board
AEZ	Agro-ecological zone
WH	Water Harvesting
RWH	Rainwater Harvesting
CMI	Community Managed Irrigation
PMI	Public Managed Irrigation
KRA	Kenya Rainwater Association
KARI	Kenya Agricultural Research Institute
NGOs	Non governmental Organizations
TOR	Terms of Reference
UH	Upper highland
UM	Upper midland
LM	Lower midland
CL	Coastal lowland
FAO	Food and Agriculture organization
ASALs	Arid and semi-arid lands
PMU	Project Management Unit
PSC	Project steering committee
NPC	National project coordinator
PAD	Project appraisal document
PIP	Project implementation plan
ENSDA	Ewaso Ng'iro South Development Authority
ENNDA	Ewaso Ng'iro North Development Authority
CDA	Coast Development Authority
TARDA	Tana and Athi Rivers Development Authority

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Executive Summary

Kenya is an agricultural country and depends entirely on agricultural production for subsistence and socio-economic development. About two thirds of the land area in Kenya is in the arid and semi-arid lands (ASALs). The pressure exerted on the fragile ecosystems that characterize the ASALs lead to severe land degradation. The agricultural sector faces the challenge of producing food for a rapidly growing population. Most of the agricultural activities in Kenya are rainfed and therefore the rainfall amount and distribution are vital components of agricultural production systems. Agricultural activities contribute significantly to the economic growth and Gross Domestic Product (GDP) of Kenya. Compared to the other sectors of development, agriculture is the main consumer of water. Due to increasing competition for water amongst other sectors, agriculture is therefore expected to produce more crop per given volume of water if agricultural production is to be sustained as a viable economic activity. There is therefore a dire need to improve water use efficiency in irrigated agriculture and also to exploit all opportunities in rainwater harvesting to supplement the conventional water supply systems.

The Nile basin forms a very important component in the agricultural production system within the Nile riparian countries. In each of the countries there are different irrigation systems and rainwater harvesting technologies that are being practiced. The improvement in water use efficiency has to be supported by knowledge and information sharing. This requires identification, documentation and dissemination of technologies and best practices from within and/or outside the Nile basin. This report is a documentation of best practices and best practice sites in rainwater harvesting and irrigation.

On rainwater harvesting, a number of technologies were described and ranked according to agro-climatic zones. The list of water harvesting technologies may not be exhaustive but the major technologies practiced in Kenya have been covered. Best practice sites were evaluated in a matrix based on a number of salient features and according to agro-climatic zones. In every agro-climatic zone, there are a number of suitable water harvesting technologies that can be implemented to alleviate water shortage. A field visit was made to Lare division in Nakuru which was chosen as one of the best practice sites on rainwater harvesting. The detailed description of the site is given in Annex 13. There is great potential for improving and scaling up water harvesting technologies. Control of water loss through seepage, evaporation and siltation need to be addressed. Water quality and sanitation around the water sources need more input in training and demonstration.

On irrigation, description was made on community managed irrigation and public managed irrigation. Due to the time limit for the consultancy, it was not possible to deal with privately managed irrigation. Most private irrigation firms do not release information about their production systems easily and thus more time is required to get useful data from them. As a result of not covering the private irrigation schemes, the terminology of public/private managed irrigation (PPMI) as given in the terms of reference was changed to public managed irrigation (PMI). This was recommended during the one day validation workshop. The different irrigation systems practiced in Kenya were evaluated in a matrix, described and ranked. Best practice sites were evaluated in a matrix based on a number of salient features. Field visits were made to some of the sites chosen as representing the best practice sites. The sites visited were Kibirigwi (community managed irrigation scheme), Mwea and Perkera (public managed irrigation schemes). The detailed information on each irrigation scheme is given in the relevant annexes. Gravity fed irrigation systems are more sustainable due to low overhead cost. Provision of stable

market for major crops grown in the irrigation schemes is a major key to their sustainability. The management of public managed irrigation schemes was more complex because of the high number of beneficiaries involved and their expectations. Lack of adequate information and supporting data on water use was limiting in evaluating water use efficiency in different irrigation systems.

There is need to organize a longer study to allow for more information gathering on specific operations of water harvesting and irrigation systems. A critical path analysis needs to be developed which would help in improving water use efficiency.

1.0 Introduction and Background Information

1.1 Introduction

Kenya has a land mass of 582,000 km^2 out of which only 16 % is of medium to high potential. The high potential area receives over 1000mm annual rainfall and accounts for less than 20 % of the agricultural land. The area carries more than 50 % of the country's population. The medium potential area receives between 750mm to 1000mm of rainfall per annum. The area occupies 35 % of the agricultural land and carries 30 % of the population. The rest of the country (80 %) is classified as arid and semi-arid land (ASAL) with mean annual rainfall of less than 750 mm and carries 20 % of the population. This shows that the country is poorly endowed with potential for rain-fed agriculture. The future growth and development of the agricultural sector will rely on integrated water resources management that encompasses water harvesting and irrigation. This study was formulated to document the best practices and best practice sites in water harvesting and irrigation. The first part of the report gives a brief background on water harvesting and irrigation, objectives of the study, methodology used and classification of agro-climatic zones in Kenya. The second part gives the prioritization and ranking of best practices and best practice sites for water harvesting and irrigation. The detailed description of best practices and best practice sites is also given in the second section. The third section gives the analysis of existing guidelines and any gaps detected, profile of institutions for collaboration and concluding remarks.

1.2 Background Information

Irrigation can improve agricultural production significantly when investments are carefully planned. Water is a limited resource and sharing it between its multiple users calls for an integrated form of management. The success of irrigation projects generally depend on the involvement of the concerned communities and comprehensive analysis of the technical, economic, social and environmental factors. There is need to increase water use efficiency, reduction of water losses, intensify research on developing new water efficient crop varieties and introduction/adoption of appropriate irrigation technologies. 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 adoption in other areas with similar environmental conditions.

Rainwater harvesting is a viable technology in areas with as low as 300mm annual rainfall. There are many water harvesting technologies that can be adopted by a wide range of people depending their economic status. Some of the technologies have not been adequately documented. There is also a gap in scaling up and extending best practices from one country/region to other areas having the same potential for rainwater harvesting. The initiative by EWUAP project to document best practices and enhance information sharing in the region will improve agricultural production and the livelihoods of many people in the Nile basin. It is upon this basic information that consultancy was requested by EWUAP to identify and assess best practices and best practice sites on water harvesting, community managed irrigation and public managed irrigation.

2. Objective/Requirement of Study

The main objective was to document and assess best practices, identify sites of best practices and provide a profile of potential institutions for further collaboration in capacity building. The specific objectives were to:

- Identify and establish list of best practices and technologies associated with water harvesting, community managed irrigation, and public and private-managed irrigation schemes nationally;
- Select few pre-eminent practices from the list of best practices and technically provide a profile or detailed description of the practices;
- Identify best practice sites for water harvesting (WH), community managed irrigation (CMI) and public managed irrigation (PMI) schemes;
- Profile the selected best practice sites with indigenous and/or modern techniques;
- Identify and list national institutions with potential to organize and conduct capacity building and field demonstration in water harvesting and irrigation.

3. Approach and Methodology Used

The study was carried out first by reading project documents supplied by EWUAP which were the project appraisal document, project implementation plan and rapid baseline assessment report for Kenya. Information on best practices (BP) and best practice sites on water harvesting, community managed irrigation and public managed irrigation was obtained by reviewing relevant documents obtained from government Ministries/institutions and NGOs dealing with water harvesting and irrigation. Criteria for prioritization of best practices and best practice sites were developed following the agreed salient features. The salient features were evaluated in a matrix upon which the best practices and best practice sites were ranked. Best practices on water harvesting were evaluated according to agro-climatic zones which were put in their major classifications as follows:

Zones I, II and III (humid to sub-humid): average annual rainfall of 1000 to 2000mm and above.
Zones IV and V (sub-humid to semi-arid): average annual rainfall of 500 to 1000mm.
Zones VI and VII (arid to hyper-arid): average annual rainfall of less than 250 to 500mm.

The salient features on water harvesting technologies were evaluated in a matrix within each class of agro-climatic zone. The technologies were ranked in order of significance. The ranking was based on evaluating the salient features and giving a score for each feature. In each technology there were the major features which were given a higher scale of 1-10. The highest score for the major features was 10 points that reflected the best situation. Average situation was given a score of 5 points while the worst situation was given 2 points. Other salient features were evaluated on a scale of 1- 8. The best situation was given a maximum score of 8 points. The average situation was given 4 points while the worst situation was given 2 points. The points were added up and the technology with the highest number of points was considered as the best practice or the practice that is widely practiced in a given area. In each class of agro-climatic zones, the water harvesting technologies were ranked by subjecting the salient features to the matrix. The same exercise was done in selecting best practice sites.

Best practices on irrigation were evaluated based on major salient features that were given a scale of 1-10. The best situation was given 10 points while the average situation was given 5 points. The worst situation was given 2 points. The other salient features were evaluated on a scale of 1 – 8 where the best situation was given a maximum of 8 points, average situation 4 points and the worst situation was given 2 points. The salient features were evaluated in a matrix. The technology with the highest number of points was considered the best practice. The same exercise was done in selecting the best practice site.

The best practices were described according to the information obtained from reference documents. In addition to the reference documents, information was also obtained from internet web sites, telephone interviews and personal communication with resource people. More detailed information on selected best practice sites was obtained by making three-day visit to validate information obtained from existing documents and assess the current situation. The information obtained helped in making detailed description of the selected best practice sites.

4.0 Zonation of Land Potential

Kenya is a country with wide variations in climate, land forms, geology, soils and land use. Elevation ranges from sea level at the Indian Ocean to the top of Mt Kenya with snow at about 5200m.a.s.l. The average annual rainfall ranges from 250 to 2500 mm, the average potential evaporation ranges from less than 1200mm to 2500mm, while the average annual temperature ranges from less than 10ºC to 30ºC. Land potential in Kenya can be based on agro-climatic zones or agro-ecological zones.

4.1 Agro-climatic zones

Agro-climatic zoning is based on rainfall amount and distribution and temperature. The main agro-climatic zones are based on their probability of meeting the temperature and water requirements of the main leading crops (Figure 1). There are many different rainfall distribution types in Kenya which make it difficult to produce a detailed agro-climatic zone classification to cater for all variations in rainfall and temperature. There are seven main agro-climatic zones in Kenya according to FAO (1978) based on the average monthly rainfall and potential evapotranspiration (Table 1).

Table 1: Agro-climatic zones based on rainfall amount

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 farming for cash and subsistence. Large farms and estates with tractor mechanization coexist with small holdings using oxen or hand labour. Major crops 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. Improved breeds of sheep, pigs and poultry are also found in these high potential areas. The main forest areas, both indigenous and planted, are found above 1,500 metres but occupy less than 3 percent of Kenya's land area.

The semi-arid areas are characterized by mixed crop and livestock farming 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. The arid and semi-arid lands (ASALs) support 35 % of Kenya's cattle, 67 % of sheep and goats and all camels. Irrigation is practiced on a relatively small but increasing scale depending on water availability.

4.2 Agro-ecological zones

An agro-Ecological zone (AEZ) is a zone which is defined by its relevant agro-climatic factors mainly the moisture supply and differentiated by soil characteristics (Figure 2). In addition to the agro-climatic factors, classification of AEZ is also based on the length of growing season, soil moisture storage and crop water requirements. There is a great influence of the length and intensity of arid periods in the classification (Table 2). The aim of AEZ is to provide a frame-work for the ecological natural land use potential. The AEZ also provides a tool for assessing which areas are climatically suitable for various land use alternatives, with particular emphasis on the suitability for crops or crop varieties. They are suited to make decisions in formulating short and long-term agricultural policy. 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. There has to be enough water supply for plants to transpire more than 40 % of the open water evaporation.

Table 2: Agro-ecological zones based on length of growing season, temperature and water requirements of main leading crops.

Main AEZ	Sub-AEZs							
	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^{o} 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 ^{o} 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 ^{o} M. min. > 11-14 ^{o}		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^{o} M. min. > 14 ^{o}		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^{o} Mean max > 31^{o}		Rice	Lowland Sugarcane	Lowland Cotton	Groundnut	Lowland Livestock & Millet	Lowland Ranching	Lowland nomadism
CL Coastal lowland zone Ann. mean > 24 ^{o} Mean max. < 31^{o}		Oil palm	Lowland Sugarcane	Coconut & Cassava	Cashewnut & Cassava	Lowland Livestock and Millet	Lowland Ranching	Lowland Nomadism

Source: Jaetzold and Schmidt 1983

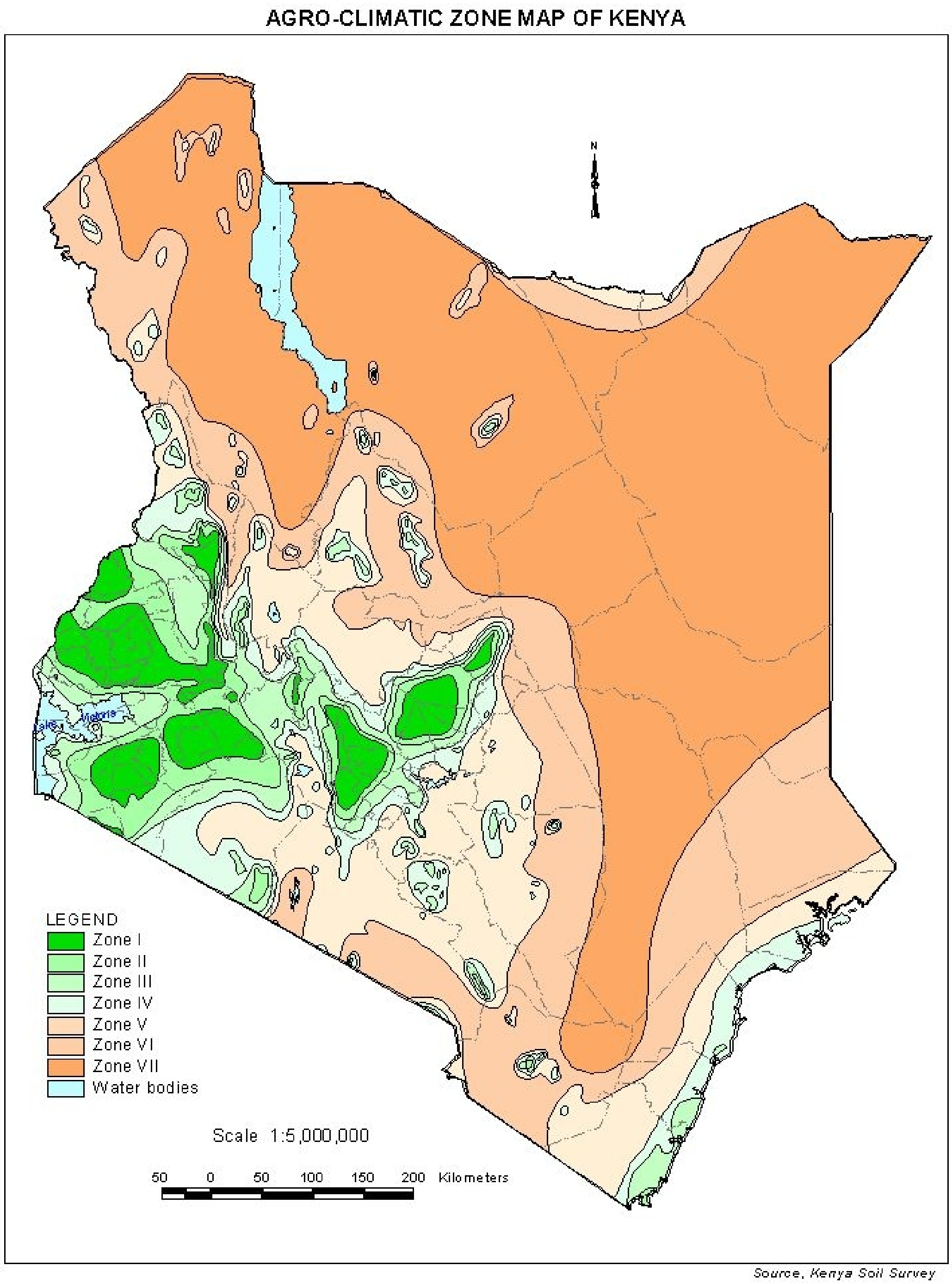

Figure 1: Agro-climatic zones in Kenya
Source: Kenya Soil Survey

Agro-ecological zone map of Kenya

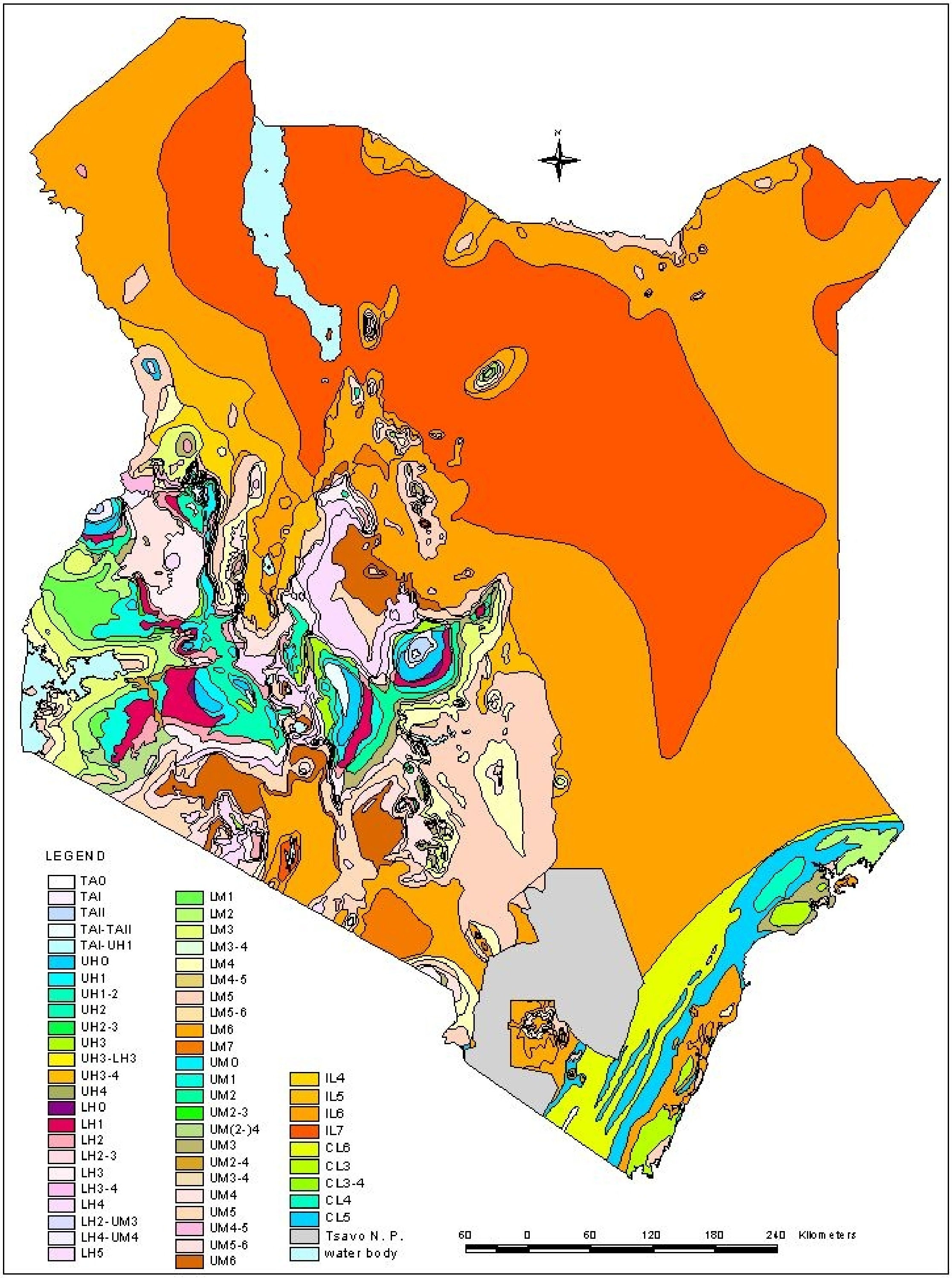

Figure 2: Agro-ecological zones in Kenya
Source: Kenya Soil Survey

5.0 Classification of Rainwater Harvesting Systems

Rainwater harvesting systems are classified according to the method collecting and managing the rainwater when it falls on the surface (Figure 3). In-situ rainwater harvesting systems involve management of rainwater where it falls on cropping land and to increase soil moisture storage for crop production without complicated water storage structures. The rainwater may be stored temporarily and used within the storage area or away from the storage area. In such cases, temporary storage structures are incorporated within the agronomic practices. Runoff water harvesting involves collecting and storing runoff water for use in supplementary irrigation or multiple uses in domestic water supply, livestock and crop production. Large runoff volumes require stronger structures and the harvested water may be stored over a longer period and be used for various production purposes.

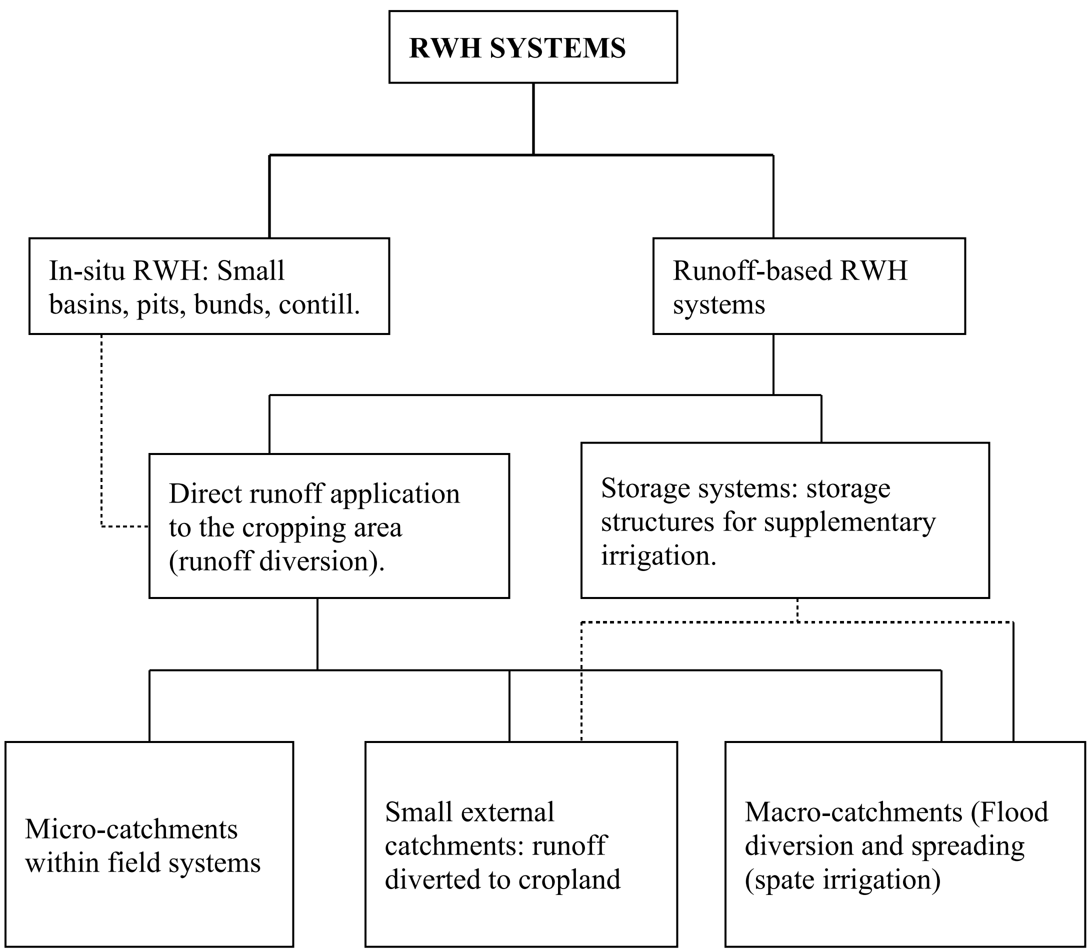

Figure 3: Classification of rainwater harvesting systems
Source: Ngigi, 2003

6.0 Criteria for Prioritization of Best Practices and Best Practice Sites in Water Harvesting

Best practices of water harvesting systems are those that cover at least most of the following attributes:

- Good example to be applicable to other areas
- Replicable to other areas with similar environment (AEZ)
- Owned, operated and maintained by the community (socially acceptable)
- Profitable
- Efficient
- Environmentally friendly to ensure the conservation of the same
- Politically acceptable in a bid to influence funding
- Sustainable
- Easy to set up
- Should use local materials as a priority

6.1 Identification and Assessment of Best Practices in Water Harvesting

Water harvesting for crop production is the simplest way in which food security can be improved in arid and semi-arid lands (ASALs). Water harvesting is a general term describing methods of collecting and concentrating surface runoff from various sources for different uses. There are two general classes of water harvesting systems; first is in-situ water harvesting, second is runoff water harvesting by various techniques of diverting and storing runoff water for domestic, livestock and irrigation. The source of runoff can be roof catchments, roadside drainage, hillside catchments or flash floods in river valleys. Most of the work on runoff water harvesting has been done manually on small scale and there were only a few cases where heavy machinery has been used. In Kenya since 1993, the Ministry of Agriculture has been supporting rainwater harvesting projects in most of the districts but the rate of adoption has been low. With the frequent cycles of drought and subsequent crop failures, there is urgent need for scaling up of water harvesting technologies that have been successfully implemented in small scale or as pilot projects.

6.2 List of Best Practices in water harvesting (WH)

Best practices of rainwater harvesting are those that have been carried out in many parts of the country and whose impacts have been realized in increasing crop yields and conserving the environment. A list of water harvesting practices/technologies that have been implemented in Kenya in different agro-climatic zones is given in Table 3.

Table 3: List of best practices in water harvesting and agro-climatic zones

Technology/Practice	Main function	Agro-climatic zone in which WH technologies are least common (+), common (++) and most commonly found (+++)						
		I	II	III	IV	V	VI	VII
IN-SITU RAINWATER HARVESTING								
Agronomic practices								
Conservation tillage	Soil water conservation, erosion control,				++	++	+	+
Double digging	Soil fertility improvement	+	+	+				
Crop residue	Soil fertility, erosion control		+	++	++	+		
Trash lines	Soil erosion control	++	++	++	+	+		
Manure/composting	Soil fertility enhancement	++	++	++	+	+		
Vegetative practices								
Grass strips	Fodder production, erosion control	+++	+++	+++	+			
Hedgerows	Fodder production, erosion control	++	+	+	+			
Structural practices								
Bench terraces	Erosion control	++	++	++	++	+		
Forward sloping bench terraces	Erosion control	+++	+++	++	+	+		
Level bench terraces	Erosion control, water conservation	+	+	++	+++	+		
Fanya juu terraces	Erosion control, water conservation	+	++	+++	+++	++		
Stone bund terraces	Erosion control			+	+	+		
Cutoff drains	Runoff diversion	+++	+++	+++	++			
Retention ditch	Erosion control Water harvesting	+	+	++	+++	++		
Waterways	Runoff control	+++	+++	+++	++	+		
Gully control check dams	Gully erosion control	+	+	+	+	+		
Micro-catchments								
Negarims	Water harvesting			+	++	++		
Semi-circular earth bunds	Water harvesting			+	+++	++		
Large trapezoidal bunds	Water harvesting				++	++		
Planting pits	Water harvesting				+	+		
Tubukiza pits	Fodder production Water harvesting			++	++	+		
RUNOFF WATER HARVESTING AND STORAGE								
Road runoff system	Water harvesting Erosion control	+	+	++	++	++	++	+
Farm ponds	Water harvesting for domestic and small scale irrigation			++	+++	+		
Water pans	Water harvesting for livestock				++	+++	++	+
Small earth dams	Water harvesting for multiple use		+	++	++	+++	+	+
Rock catchment dams	Water harvesting for domestic use				+	+		
Sand dams	Water harvesting for multiple use				+	+	+++	++

6.3 In-Situ Rainwater Harvesting Systems

In-situ rainwater harvesting systems deal with technologies that enhance rainwater storage in the soil profile for increased land productivity. Such systems can be categorized as: agronomic, vegetative and structural measures. In-situ rainwater harvesting system aims at conserving and utilizing rainfall where it falls. The system entails increasing the amount of soil moisture stored in the soil profile.

6.3.1 Agronomic measures

Agronomic measures include; conservation tillage, double digging, crop residue management, trash lines, manure and composting.

6.3.1.1 Conservation tillage

Description

Conservation tillage, including minimum and zero tillage practices, is one of the most promising means of reducing soil erosion and increasing crop yields under rainfed farming systems in the arid and semi-arid areas. Minimum tillage involves limiting manipulation of the soil while zero tillage entails direct planting without any soil disturbance with herbicides use. The system requires leaving at least a fifth of the crop residue in the farm after harvest. The soil cover not only reduces evaporation from the soil surface but also protects the soil against wind and water erosion. Conservation tillage in Kenya has been practiced in Laikipia, Nakuru, Bungoma, Siaya, Machakos and Mbeere districts. Majority of conservation tillage adopters are large scale farmers whose goal is to reduce production costs so as to remain in business. In Laikipia district, conservation tillage is practiced on a number of large scale wheat farms that are using mechanized equipment in conjunction with herbicides. One system is to use disc harrows to break up the crop residues and a deep tined cultivator to loosen the ground and undercut weeds. Despite efforts by several organizations to promote conservation tillage among small scale farmers, adoption was still limited to a few individuals and farmer groups. On small farms, ox-drawn rippers and hand tools have been used with beneficial effect to break through hard pans and loosen the soil.

Benefits

Farmers practicing conservation tillage progressively increase their crop yield. The effect of conservation tillage on households infected or affected by HIV and AIDS has shown reduced labour demands and increased household nutrition and food supply. This has motivated many people to adopt the technology. Minimum tillage maintains good soil structure that enhances soil water movement and increases biological activity in the soil. The presence of crop residues on the soil surface minimizes evaporation losses, conserves soil moisture and increases crop water use efficiency and hence increasing crop yields.

Limitations

Implements for conservation tillage are not readily available because they have not attained large scale industrial production. It is hoped that with more farmers adopting the technology, there will be increased production of the implements for a ready market.

6.3.1.2 Tied ridges

Description:

The principle behind tied ridges is to increase soil moisture storage by first making ridges and furrows, then damming the furrows with small mounds or ties. Tied ridging is most appropriate in deep soils with good infiltration and permeability such as loamy, sandy loam and clay loam soils. Tied ridging has been reported in a number of areas as successful. The work done in Katumani Dryland Research Centre in Kenya shows that tied ridging resulted in the production of a crop of maize in low rainfall years when the flat-planted crops gave no yield (Njihia, 1979). A study done in Koibatek district in rift valley, Kenya, showed that tied ridging gave higher maize yields than in conventional flat planting (Kipkech and Kipserem, 2001).

Benefits:

Tied ridging has increased mean crop yields by more than 50 percent in maize, sorghum and millet compared to planting on flat land. Tied ridges increase soil water storage and also enhance good distribution of rainwater in the cropped area for maximum crop yield.

Limitations:

The technology is labour intensive in making the ridges using hand labour and is therefore limited to small areas. On a large scale the use of ox-drown or tractor-drown implements like furrow opener or ridger would solve the labour problem and improve the efficiency of making the ridges to cover more ground.

6.3.1.3 Double digging

Description

Double digging involves digging soil to a greater depth than commonly done to break up hard pans and improve rainwater infiltration. It is normally combined with the application of compost manure.

Benefits:

Maize yield increase of up to 40% has been reported in Busia district.

Limitations

The high labour requirements and so can only be done on small scale.

6.3.1.4 Crop residue management

Crop residues are commonly available on large farms and in humid areas. In the drier areas residues are destroyed by termites fairly quickly. Crop residue can be left as surface mulch or incorporated into the soil during land preparation.

Benefits:

Crop residue is effective in controlling weeds and evaporation losses when applied as surface mulch. There is protection of soil against the impact of raindrops. Runoff water is slowed down and thus controls soil erosion. Crop residue maintains high level of organic matter in the soil.

Limitations

There is high competition with other uses like livestock feeding and source of fuel for cooking.

6.3.1.5 Trash lines

Description

Trash lines are composed of crop residue laid along contours at specific vertical interval. This is one of the oldest technologies for erosion control. They may also be used as a way to dispose of crop residues so that the land can be cultivated.

Benefits:

Trash lines impede runoff and accumulate sediment which minimizes soil loss. If they are maintained in the same place for a number of years, terrace profile may be formed.

Limitations

There is high crop residue damage by termites in some agro-climatic zones especially in the ASALs. There is also high competition of crop residue with other uses like livestock and source of fuel for cooking.

6.3.1.6 Manure and composting

Much attention has been paid to the use of manure and compost in the last 20 years. This has been due to the activities of NGOs such as Kenya Institute of Organic Farming (KIOF) which has trained many farmers in the best ways of making compost and manure from crop residues, wood ash, and hedge trimmings. The problem of declining soil fertility and rising cost of inorganic fertilizers has added impetus to organic farming methods.

Benefits:

Manure improves soil quality in terms of nutrients, physical characteristics, structure, water holding capacity and cation exchange capacity. The soil improvement would lead to increased crop yield.

Limitations:

The nutrient quality of manure is often low because of exposure to rain and sun in open ground as well as poor management after removal from the livestock sheds.

6.3.2 Vegetative measures

Vegetative measures include; grass strips and hedgerows.

6.3.2.1 Grass strips

Description

Grass strips have been promoted since the start of the National Soil and Water Conservation Programme in 1974. This technology assists in control of soil erosion and leads to the development of terraces with minimum labour. The most commonly used grass is napier grass (*Pennisetum purpureum*), but other shorter grasses such as Signal grass (*Brachiaria decumbens*) are used as well. Grass strips are laid along the contour at a width of one metre or less depending on the size of land. Maintenance involves weeding, filling gaps, manure application and harvesting of fodder.

Benefits:

Grass strips have been very popular and have been adopted spontaneously in the humid areas where farm holdings are small and livestock are stall fed.

Limitations:

There is high competition for water and plant nutrients between the grass strips and the adjacent field crops. Grass strips also provide a refuge for rodents and other crop pests.

6.3.2.2 Hedge rows

Description

Hedgerows in cropland for erosion control comprise rows of shrubs or well-pruned trees planted along the contour. The hedges can either be single or double rows at normal terrace spacing according to ground slope. Multipurpose shrubs and trees which can be pruned for fodder, mulch and fuel wood have proved to be useful as hedgerows. Plant species like *Calliandra calothysis* has proved popular in Embu district. Hedges are common on farm boundaries and *Tithonia diversifolia* is planted for this purpose but it also grows naturally.

Benefits

Hedges are used to impede runoff and control erosion. The prunings can be used as fodder for livestock or surface mulch whichever is applicable in a particular case. Some hedges are nitrogen fixing species and help to improve soil fertility.

Limitations

There is high competition for water and nutrients between the hedge row trees and field crops. Regular pruning is required to minimize competition for light with the field crops.

6.3.3 Structural measures

6.3.3.1 Bench terraces

Description

Bench terraces are constructed on steep land between 12 to 58 % considering the various land use types. The terrace in most cases converts a steep slope into a series of steps, with nearly horizontal benches to reduce velocity of runoff, reduce the rate of soil erosion and increase crop yields. Bench terraces are suitable in moist and medium rainfall areas with deep and well drained soils. They are also applicable in semi-arid areas on gentle slopes and well drained soils.

Benefits

The technology is generally applied on cultivated lands. Bench terraces are highly effective in soil and water conservation and the benefits are realized within a short time. There is improved water retention on the benches and provides sufficient time for water to infiltrate into the soil profile

Limitations

Construction work is labour intensive and requires additional input in terms of labour and money. Oxen cultivation may be difficult in narrow spacing. Design and construction of bench terraces require consideration of the farming system. There is exposure of the sub-soil in the excavated area that requires amendments to improve on the soil fertility. This is overcome by heaping top soil on one side and spreading it uniformly over the excavated area after levelling the bench. This increases the cost of construction because of extra labour for separating and spreading the top soil.

6.3.3.2 "Fanya juu" terrace

Description

This is a type of terrace constructed by excavating a trench normally one metre wide and 0.6 metre deep and heaping the excavated soil up-slope of the trench to form an embankment. "Fanya juu" is a Kiswahili expression of the art of constructing the terrace, meaning "working up". The terrace can either be graded or level. Graded terrace is suitable mostly in high rainfall and humid areas of wetter agro-climatic zones and especially where the soil is poorly drained. Level terraces are constructed in dry areas to combine both soil and water conservation. The main objectives are to keep rainwater where it falls and to retain the soil in the field. "Fanya juu" terraces have been implemented in many districts in Eastern and Central provinces. Where several of these terraces are constructed across a field, the terraced land develops the characteristic "steps" of bench terraces with time. The technology is best suited for slopes of 5-30 % where other soil and water conservation technologies may not be feasible. Irrespective of the land slopes, the terraces have vertical intervals ranging from 1.2 - 1.8 metres. Runoff and sediment accumulate on the upper side and, after some years, the "fanya juu" terrace may form a profile. "Fanya juu" terraces have been widely used in the drier areas of Kenya where the need to conserve water is greatest. In this situation they are normally laid out level from end to end. They have been adopted spontaneously on many farms and have been promoted by the National Soil and Water Conservation Programme under the Ministry of Agriculture.

Benefits:

Terraces increase crop yields due to increased moisture availability, conservation of plant nutrients and enhanced infiltration. Terracing reduces the slope length and gradient and controls surface runoff. The terrace embankment traps runoff water and gives it more time to infiltrate, while the channel acts as a retention ditch. The channels have been used to store water directed from the roadside drainage and fruit trees planted in the channel benefit from the harvested water. This increases land productivity. The terrace has the capacity to become a bench terrace within a short time if frequent maintenance is applied. However its contribution to increased productivity is assured if well managed and integrated with soil fertility improvement practices.

Limitations:

One of the limitations of “fanya juu” terrace is usually inadequate labour on the farm for construction since it is labour intensive. A farmer therefore requires an initial capital or family labour to construct terraces on a large scale depending on the size of the farm. The technology is not suited to grazing areas because of difficulties in cattle crossing. The embankment is not cultivated and such space is put out of production which can be of great concern in small scale farms. This limitation can be overcome by planting grass on the embankment which can be cut and fed to the livestock.

6.3.3.3 Cut-off drains

Description

A cut-off drain is a graded channel constructed to intercept and divert the surface runoff from higher grounds/slopes and protect downstream cultivated land or settlement. This safely diverts the runoff to a waterway, river, gully or stable ground with minimum risk of further erosion. Cut-off drains have been widely used to intercept runoff and discharge it safely to a convenient point. They are also referred to as diversion ditches, storm drains and their main function is to reduce the risk of soil erosion by water and in particular to prevent gully erosion.

Benefits

A cut-off drain is suitable on a steep hillside under which cultivated fields are exposed. They are constructed above gully heads to divert runoff from active gullies to facilitate gully erosion control and rehabilitation.

Limitations

High risk of erosion at the outlet if drop structures have not been well constructed.

6.3.3.4 Retention ditches

Description

A retention ditch is an open channel with no gradient and is designed to retain runoff. It has no exit and the runoff from the catchment area is stored in the ditch and with time it infiltrates into the soil profile. Such structures are constructed in high rainfall areas where land holdings are small and farmers may not be willing to spare land for cut-off drains and waterways construction because of high opportunity cost.

Benefits

There is significant reduction of surface runoff and hence reduced surface erosion.
Infiltration of water increases soil moisture storage capacity for the benefit of growing crops. Water infiltration also replenishes ground water table from which other deep rooted vegetation would grow well and have a positive impact on environmental conservation.

Limitations

The system is not suitable in areas that are prone to landslides because holding too much water in the soil profile would increase the pore water pressure that would trigger landslides. The system is suitable in highly permeable soils that would minimize the risk of overtopping in case of unexpected high rainfall events. There is high risk of failure that may cause more damage down the slope if the capacity of the ditch is less than the expected volume of runoff. The stored water has high potential energy which may cause more erosion damage in case of failure of the ditch.

6.3.3.5 Waterways

Description

A waterway is a natural or artificial drainage channel to accommodate runoff from cut-off drains and graded terraces. The waterway conveys the runoff and safely discharges into stable areas without causing erosion. Waterways can be constructed for small and large size catchments, thus accommodating individual or communal needs for drainage of excess runoff. Paved waterways are suitable in steeper terrains and areas with large amounts of stones. Under such conditions a steeper gradient can be designed because of low risk of erosion. Vegetated waterways are recommended in areas with high risk of erosion where the gradient needs to be kept low but high enough to minimize siltation of the channel.

Benefits

Waterways are applicable in all agro-climatic zones particularly in moist areas and areas prone to water logging. There is high contribution to increased sustainability of production through disposing excess runoff from cultivated fields and other sources of runoff from up-stream. They help to reduce soil erosion and gully formation. Waterways also act as conveyance for runoff water harvesting which can be stored in a constructed structure for use during the dry season.

Limitations

There is high risk of silt accumulation that may lead to failure of the waterway due to reduced capacity. Regular maintenance is required in desilting and clearing of vegetation.

6.3.4 Micro-catchment systems

These involve runoff generation within the farmer's field. The land is therefore sub-divided into micro-catchments that supply runoff to the cropped area. The concentrated runoff is directed on to either:

- a single crop in fruit trees like Pawpaw, Orange or Mango
- a group of crops like Maize and Sorghum
- row crops with alternating catchments and cropped area along contours.

Examples of micro-catchment systems include:

6.3.4.1 Negarims

Description

Negarims are regular squares or diamond shaped soil bunds turned by 45° from the contour to concentrate run off water at the lowest corner of the square. It means they are oriented to have the maximum land slope parallel to the long diagonal of the diamond. This is to ensure that runoff flows to the lowest corner where the plant is placed. At this corner, an infiltration basin is made. At the centre of this basin, a planting pit is dug. The whole square consists of a catchment area and a cropped area. Runoff collects from the catchment area and flows into the cropped area where it ponds, infiltrates and is stored in the soil. Negarims can be used in very dry areas and are best suited on even ground. The area of each unit is determined on the basis of a calculation of the plant (tree) water requirement or, an estimate of this based on experience. Depending on dryness of the area and tree species, the size of micro-catchment per unit basin normally ranges between $10m^2$ and $100\ m^2$. The bunds should be at least 25 cm high to avoid overtopping. The top width is at least 20 cm wide and the side slopes 1:1. On steeper slopes, the bund height should be increased especially near the infiltration pit. The pit should be 60cm x 60cm x 60cm with the subsoil being used for bund construction.

Benefits

They are most suitable for growing tree crops and establishing trees in dry areas. When used for fruit trees, Negarims are designed to provide sufficient moisture to a producing tree. The soil should be deep enough to hold sufficient water.

Limitations:

The technique requires deep soils up to 2 metres to store the harvested runoff. They are best on gentle slopes (1-2%) but can be used up to 5%. If used beyond this, erosion is a problem. They are limited to manual construction i.e. they do not allow mechanization.

6.3.4.2 Semi-circular earth bunds

Description

These are usually earthen bunds in the shape of a semi-circle or a crescent with the tips facing directly up slope. They are created at a spacing that allows sufficient catchment to provide the required runoff water, which accumulates in front of the bund, where plants are grown. The sizes of the bunds vary depending on the crop type, soil and the rainfall amount. The space between tips of consecutive bunds is used for discharge of excess runoff. The top width of the bunds is usually 10 cm and the height may be uniform where the topography is flat. The side slopes are 1:1 although flatter sides are also possible. As the slope increases, the height is increased accordingly from the tip to the lowest point. The minimum height at the tip is 0.1 m. When they are smaller they can be used on steeper slopes of up to 5%. Two distinct designs are used depending on whether the crop is a tree or a row crop. While the geometry of the bunds is the same, if the crop is cereal the diameter tends to be large and small for the case of a tree crop.

Benefits:

The bunds are used mainly for the rehabilitation of rangeland or for fodder production, but may also be used for growing trees, shrubs and in some cases field crops like sorghum.

Limitation:

They are limited to manual construction on gentle slopes of less than 5 %. Semicircular bunds are used in areas of 200-750mm rainfall, deep soils and low slopes (2 - 5%) and even topography.

6.3.4.3 Large trapezoidal bunds

Description

This technique is suitable for areas with 250 to 500mm of annual rainfall. It consists of large structures enclosing up to 1 ha and impounding large amounts of run off from an external area. Food crops such as sorghum or miller are planted in the cropping area enclosed by soil bunds. The impounding bunds are laid along the contour but staggered down the slope to allow release of excess runoff. Excess runoff is discharged around the tips of the bunds and collected in the next bund down the slope. The basic principle of construction is that the length of the wing wall is equal to that of the base bund. For food crops like sorghum or millet, single bunds occupying an area of between 0.5 and 1 ha each are constructed on lopes of 2 % and the space between the bund tips can be between 10 and 40m long. The most suitable slopes are 0.25 to 1.5 %, but can be used up to 7 % slope on even topography and on non-cracking soils such as black cotton soil. The maximum bund height is 0.6m decreasing to 0.2 m at the tips. The side slope of the bund can vary from 1:1 to 4:1 and standard top width is 0.2 m. It is mostly suggested that the base bund should be equal in length to the wing wall. The height of the walls depends on land slope. On slopes up to 1.5% length of bund tips can be up to 120 m. The technique can be used for trees and grass but is best suited for row crops where manual work is the system of cultivation.

Benefits

The system has been implemented in areas of Turkana in Rift Valley province for sorghum production, trees and grass establishment in grazing land. The bunds increase water storage in the soil for crop production.

Limitations

The labour requirement for constructing the bunds is high since this is done manually. Crops grown should be those that would withstand temporary water logging such as sorghum and millet.

6.3.4.4 Planting pits (Zai pits)

Description

This is a system of small pits dug along approximate contours that allow the cultivation of crops on degraded lands. It consists of digging holes to a depth of 5–15 cm. Manure and different kinds of grass are mixed with some of the soil put into the pit. The rest of the soil is used to form a small dike down the slope of the pit. Pits are applied in combination with soil bunds to conserve runoff, which is slowed down by the bunds. The system has been used in Mwingi district to grow maize and sugarcane along the banks of a seasonal river after flood recession. The system was initiated by a farmer after El-nino rains of 1997/98. During that time, large amounts of sand (about 1 metre deep) was deposited on his farm rendering it uncultivable. In an attempt to reclaim his land he noticed that beneath the sandy layer, there was adequate moisture in the soil. He was able to grow a crop with residual moisture throughout the dry season before the rains in the subsequent season. The sandy layer acts as a surface mulch in preventing water loss through evaporation. The technology can be applicable in many sandy rivers provided the underlying soil profile is not too deep to be reached by plant roots. The cultivated pits in Mwingi district were 45 cm wide and 90 cm deep. Planting pits have also been used in range rehabilitation. Pits are dug in the rangeland to trap the surface runoff for establishing vegetation and grasses to increase biomass production for livestock feed.

Benefits

Pits increase crop yield by a combination of moisture conservation and harvesting of runoff from the space between the planting pits. The system increased maize yield from 0.7 – 3.8 tons per hectare in Mwingi district. The farmer who started this innovation was regarded as a resourceful person by the community. Other farmers adopted the technology and food production in the area was increased.

Limitations:

Performance of the system depends on the amount of rainfall during the rainy season. When the amount of rainfall is low, the stored moisture may not be enough to support the crop to maturity. There are limited numbers of sandy riverbeds with suitable sites for this kind of system. Topography is a limiting factor because it will not work in steep areas. The technology is therefore limited to the lowlands. Labour requirement for digging the pits is high.

6.3.4.5 Tubukiza pits for fodder production

Description

The technology involves planting fodder grass in pits excavated at 0.9 metre diameter and 0.6 metre deep. The top soil is separated from the sub-soil during digging. The top soil is then mixed with manure and used to fill the pit where 20-25 cuttings of napier grass are planted leaving small depressions on the surface for trapping rainwater. The technology has been widely practiced in Laikipia district. Three years after introduction of the technology, many farmers in the district had adopted it and the trend has been continuing. Tubukiza provide a very adaptable way of growing fodder in the ASAL.

Benefits:

The impact of the technology has been positive in the area where persistent drought has reduced dairy production. Dairy farmers in the ASALs are able to increase their milk production because of increased fodder production through tubukiza pits. In Laikipia district the technology had the potential of increasing household gross incomes by about USD 58 per month with no extra recurrent input. They combine fertility management with water harvesting and conservation. The technology is well adapted to zero grazing set up in livestock farming where grass is cut and carried to the feeding lot. The technology is also suited to high rainfall areas with high population density and small land holdings.

Limitation:

The technology is labour intensive in excavating the pits. However the long-term benefits supersede the cost of implementation.

6.4 Runoff Water Harvesting and Storage

This involves harvesting and storing rainwater for use either close to the area of storage or away from the storage area. There is distinct area for generating runoff and specific storage area or structure. The stored water may be used in an area far from the storage area and therefore a conveyance system is required. Rainwater harvesting systems with storage for supplemental irrigation are becoming popular in ASALs of Kenya. In the semi-arid parts of Laikipia district, underground water tanks (50-100 m^3 capacity) have been promoted for vegetable gardening. The tanks surfaces are usually sealed with ultra resistant polythene lining, mortar, rubble stones or clay to reduce seepage losses while covering the tanks, with either local material (thatch or iron sheet) to minimizes evaporation losses. Seepage control remains a major challenge in ground water tanks. There are many runoff water harvesting systems, some of which are described in this report.

6.4.1 Farm ponds

Description

Farm ponds are excavated water storage structures without a constructed wall. They usually store surface runoff, even though there are examples of constructed ponds storing water from roof catchments. Excavated ponds vary in size depending on the number of people using the water facility. This can vary from household level of $500m^3$ up to community level of $10,000m^3$. Farm ponds can easily be started with a small capacity and expanded over the years by digging deeper and wider. In areas with impermeable soils and a suitable site, the only cost of construction is the labour. A community can dig their own pond with little cash expense. Ponds should be situated at a low point in the catchment area so that runoff flows by gravity to the excavated pond. The catchment area can consist of any type of surface such as cropland, grasslands or compounds around homesteads. Hard road surfaces or rock outcrops may also make suitable catchment areas. Surface runoff can be diverted from a nearby gully, provided the pond is situated at a lower elevation than the gully. Soil excavated from the pond can be used to make soil bunds for diverting runoff to the pond. Farm ponds can have different shapes and sizes although circular design is common. They are mostly built in flat areas or inclined slopes. The size of the pond will depend on the following factors:

- The water demand plus silting allowance. Normally 10 per cent of the storage is left for silting.
- The size of the catchment area draining into the pond and the expected volume of runoff water from the catchment.
- The area available for constructing the pond
- The soil type
- Resources available for construction.

Most farm ponds are constructed manually and the main expenses are hand tools and labour for excavation. A medium community farm pond may cost about USD 1,500.

Benefits

Farm ponds have been effective in meeting the water demands for the community in a number of months between the rainy seasons. Depending on the population and water demand, a typical farm pond would keep water for about five months. If there is no prolonged drought, it is possible that the stored water may last the community to the next rain season. Farm ponds can be constructed both in high and low rainfall areas. However more ponds have been constructed in the arid areas than in the high rainfall areas due to acute water shortage in the ASALs. Examples of the areas where farm ponds have been construct include Laikipia, Bondo, Nakuru and Kiambu districts.

Farm ponds can be sited close to the homesteads and will increase water availability to the community. Reduced walking distance to the water sources will save time that can be used in other development activities. There is environmental conservation because of reducing the amount of surface runoff in an area. Water seepage from the ponds also raises the ground water table that enhances establishment of vegetation and will control land degradation. Farm ponds have positive environmental benefits through control of surface runoff, ground water table recharge due to seepage, and enhancing vegetation establishment in control of land degradation.
There is increased water supply to the community and individuals. The ponds can be easily constructed because there is no demand for construction materials apart from hand tools and local labour. They can be constructed in any environment where the soil conditions are suitable for retaining much water with minimum seepage losses. Farm ponds have been constructed in many parts of Eastern, Rift Valley, Central and Nyanza provinces. There is high potential of developing farm ponds within the Nile Basin.

Limitations:

The storage capacity of most ponds is too small to supply sufficient water throughout the long dry season. High evaporation losses are difficult to address on the hot, wind swept plains where most ponds are located in the arid areas. Reduced storage capacity due to siltation is sometimes made worse by lack of silt traps or where sides of the ponds are so steep that they collapse. Farm ponds may have the problem of breeding mosquitoes that may increase the incidence of malaria outbreak. Open ponds are risky for children and animals drowning if not protected by fencing around. There is high risk of water contamination either by the condition of the catchment or the form of water abstraction from the pond.

Operation and maintenance:
Depending on the ownership of the pond, it is assumed that a committee or individual takes the responsibility of managing the pond. In case of a community pond, the mandate of the management committee is to ensure that the agreed by-laws are adhered to and that funds are handled properly. A monitoring and evaluation system should also be in place for the committee to follow, and when necessary seek advice or technical help from external sources. Operation entails balancing water demand and supply and scheduling abstraction. Maintenance entails prolonging the lifespan of ponds through routine maintenance, repairs and desilting. It is advisable to control access to the pond to reduce contamination. A fence should be built around the pond to keep people and livestock from direct access to the water. Water abstraction mechanism should be provided to avoid contamination.

6.4.2 Water pans

Description

Water pans are excavated with an embankment and provision of a spillway. Natural depressions can also be modified to increase water storage volume. Water stored in natural depressions has been used by wildlife, livestock and local human community for a long time in many parts of the country. Water pans are used for watering livestock during rains and a few months thereafter. Some people also use them for domestic water supply. Water pans have been developed on borrow pits or murram pits found along roads. They are formed when murram is dug up for road construction. These pits fill with runoff from the road during rains. Such can be converted into useful small reservoirs for livestock, irrigation and fish ponds. This is because most borrow pits are dug in firm laterite soils, with little seepage and are capable of storing water for long periods. They can be easily filled by directing the road runoff through trenches into the pit. Natural pans have developed in some arid and semi-arid areas where they have been scooped out by elephants. The floors of such pans are almost water tight, as animals trample and compact the soil and droppings when they enter the pans to drink. Constructed water pans are usually on inclined slopes.

A detailed topographical survey should be done to establish elevations at different sections of the proposed construction site. Feasibility study has to be done to evaluate suitability for water pan construction in considering soil type, topography, size of water pan in relation to water demand and mode of construction. The embankment should be highest in the middle opposite to the inlet of the pan. Construction is less complicated and the success of a water pan depends on soil compaction at the embankment. The excavated soil forms the embankment around the pan. The soil should be placed in a way that its weight will not endanger the stability of the sides. There should be provision for a spillway to minimize the risk of embankment failure. The pan should be shaped according to the designed slopes once the correct depths have been achieved. The embankment should be progressively shaped as the excavation work continues. In addition to constructing new water pans, it is sometimes worthwhile deepening or enlarging existing natural pans where appropriate. Water pans have been constructed mostly in the pastoral areas primarily for livestock watering. Some people also use them for domestic water supply. Water pans have been constructed in Kajiado, Baringo and Laikipia districts and some parts of Nyanza province. There is a large potential for water pans development within the Nile basin.

The cost of water pan construction depends on the size and mode of construction. A standard community water pan of 10,000m^3 constructed with machinery would cost about USD 20,000. Water pan construction requires external technical input in survey and design. Community participates in clearing the site for construction and provision of any other unskilled labour when required. There are no complications in designs and can be easily implemented by the community with some technical guidance.

Benefits:

There is increased availability of water for livestock and community water supply. The water pans can be easily constructed because there is no demand for construction materials apart from excavation and compaction of soil at the embankment. Water pans can be constructed in many places where the soil conditions are suitable for retaining much water with minimum seepage losses.

Water pans have been effective in meeting the water demands for livestock in the arid and semi-arid areas. Depending on suitable sites, many water pans can be constructed in a given area. They can be distributed in such a way as to reduce concentration of livestock in a few places and minimize land degradation. Water pans have benefited the pastoral communities by increased availability of water. Reduced walking distance to the water sources improves condition of livestock and increases productivity. Water pans have positive environmental benefits through control of surface runoff, ground water table recharge due to seepage, enhancing vegetation establishment in control of land degradation.

Limitations:

Water pans are usually large and shallow. The large surface area exposes the stored water to high evaporation losses. As runoff water collects from the surrounding catchment, there is high sediment load deposited in the water storage area. The sediment accumulation reduces the storage volume. Malaria outbreak may increase due to mosquitoes breeding in the standing water. Open water pans are risky for children and animals drowning if not protected by fencing around. There is high risk of water contamination either by the condition of the catchment or direct abstraction by people and livestock.

Operation and maintenance:

The management of water pan entails control of animals from damaging the embankment, repair of weakened areas of the embankment and regular desilting of the pan to maintain the design capacity.

6.4.3 Small earth dams

Description

Earth dams involve survey, design and careful construction methods that require experienced technical assistance to supervise the construction. In many cases earth dams are situated in seasonal water courses which flood during heavy rains. Spillway must be designed to discharge surplus water safely. The dam wall must be strong enough to withstand several metres of water pressure from flash floods. Construction of earth dams should always be supervised by an experience person who should always seek advice or a second opinion from skilled engineers where need arises. This is because failure of an earth dam may have disastrous consequences. Feasibility study should be done to get good information of the site. This will give a fair idea on how the dam will look like and what costs are involved. Detailed topographical survey is done and the dam wall and spillway clearly located on the map. On the topographical map, the shape of the water reservoir is marked, which gives the maximum width, maximum depth and the throw-back indicating the full length of the reservoir when it is full of water.

The feasibility study and the survey results help in calculating the storage capacity based on the height and length of the dam wall. Dam walls must be built with at least 30 per cent allowance for settlement. A spillway should be sited at a distance of at least 10 m from the ends of a dam wall to avoid flood water eroding the dam wall. Construction should only be during the dry season when there is very little risk of heavy rainfall. A dam wall under construction can easily be swept away by runoff. Earth dams have been constructed in many parts of Kenya including Central, Eastern, Rift Valley, Western and Nyanza provinces. Earth dams have been constructed for land reclamation where large gullies have developed. This has been done in some parts of Machakos district where the reclaimed land is used for agricultural production. Water stored in the earth dam is used to irrigate the reclaimed land downstream. The cost of earth dam construction will depend on the design storage volume and site characteristics. A small earth dam with a capacity of 5,000m^3 may cost about USD 10,000.

Benefits:

Earth dams have been effective in large water supply systems in rural towns. The volume of water stored is large and would normally last from one year to another without drying out. Earth dams have positive environmental benefits through control and regulation of river flow and hence reduce flooding downstream during peak floods. The large volume of water stored can be of multipurpose use for domestic, livestock and irrigation that improve the livelihood of the community. Water seepage recharges ground water table and can be abstracted through shallow wells that may be dug downstream of the dam wall. There is increased availability of water for multipurpose use. The large volume of water stored can last for many months before the next rains.

Limitations:

Earth dams are more expensive to construct than other water storage structures. Due to high cost of construction only a few earth dams can be constructed in a given area. This means that some people would still walk longer distances to the water source than others. Malaria outbreak is an issue to consider as a result of mosquitoes breeding in the standing water. Earth dams are risky for children and animals drowning if not protected by fencing around. There is high risk of water contamination either by the condition of the catchment or direct abstraction by people and livestock.

Operation and maintenance:

Management of the water system entails control of soil erosion within the catchment to minimize the rate of siltation, repair of the embankment and the water distribution system. In some cases the community may get external support from development partners in constructing the earth dam. The project can also be self-help by the community. Where an earth dam is constructed using machinery, the construction work is usually given competitively through tendering system according to given specifications.

6.4.4 Rock catchment dams

Description

Rock catchment dams are constructed in areas with rock outcrops covering large surfaces. The objective is to direct the high runoff volume on the rock surface to a storage place. In Kitui district there are more than 400 rock catchment dams. Other areas are Machakos, Makueni, Mwingi and Taveta districts where rock catchments have been constructed. The runoff on the rock surface is directed to a reservoir by long lines of garlands made of rocks mortared onto the rock surface. A water reservoir is constructed at a lower level to store the collected runoff. A rock surface of one hectare can provide 1,000 cubic metres from every 100 millimetre of rain. For example: If an ASAL area has two rainy seasons and each season has a rainfall of 300 mm, then 1 acre (4,049 square metres) of rock surface can provide 300 mm rain × 2 seasons × 4,049 sq. m. = 2.4 million litres of runoff water annually. If a family uses 100 litres of water per day, then the rock in this example can provide water for 66 households throughout the year. However some water will be lost through evaporation.

For a roofed rock catchment dam, evaporation loss is about 10 % while it may be as high as 50 % for an open rock catchment dam. Usually rock catchments are built by self help groups. The construction is labour intensive. Construction is during dry period when the demand for water is highest and labour demand for other works is lowest. Food for work programmes have been used in construction work. Rock catchments consist of four components: catchment area where large fissures are sealed with cement mortar or concrete, garlands of gutters to divert runoff from the catchment to a reservoir. Water reservoir can be a water tank or rock catchment dam with a tap for water extraction.

Areas with hard granitic or basement system rocks are suitable for rock catchment dams. Examples of suitable rocks include: long narrow rocks of granite (whalebacks) rising from flat land that commonly occur in Tsavo, Inselbergs that are large and dome shaped protruding from flat land found in Voi, pediments which are exposed rock surfaces at the top of hills in some areas in Machakos, Kopjes which are rocks protruding from the ground and underground rocks that are identified by the stunted growth of vegetation as found in Wote in Makueni district.

The cost of construction will depend on the size of the dam wall or storage reservoir. The cost for 50 cubic metres dam wall would cost about USD 6,000. The community contribution in locally available materials, skilled and unskilled labour is about 49 % of the total construction cost.

Benefits:

Rock catchments have been very effective in areas where they have been successfully constructed. There are some rock catchments in Machakos and Kitui districts which were constructed in the 1950s and are still being used. There is one particular rock catchment dam in Mutomo division which was constructed more that fifty years ago and it is the only source of water to the local town. The benefits of the water harvesting system are increased water availability close to where people live, provision of relatively clean water where the rock catchment area has been maintained clean and livestock kept off the area. Rock catchments are the most economical and reliable water source in ASALs and desert regions with saline ground water and low rainfall. Little amount of rain falling on large rock surfaces can provide huge volumes of runoff water. Rock catchments have positive environmental impacts because of reducing the volume of runoff which would otherwise cause soil erosion in the lower areas. In places where there are many rock outcrops, many rock catchment dams can be constructed and will increase water availability to the community. The major expense is the construction of storage tank or open reservoir. Most of the materials needed for construction apart from cement and reinforcement bars can be easily obtained at the site.

Limitations:

The rock surface provides the catchment area for runoff. The volume of water harvested depends on the extent of rock coverage. There has to be adequate rock surface area to justify the construction of storage tank or open reservoir. The quality of water might be low if a catchment and reservoir are not cleaned before rainy season. It is believed that the sun's ultraviolet rays will sterilize most contaminants. Mosquitoes breed in open reservoirs and spread malaria. Tanks and dams without roofs have high evaporation losses. Construction of roofed storage tanks significantly reduces the evaporation losses.

Operation and maintenance:

Rock catchment dams have been constructed on self-help basis by the community. There have been cases of assistance by development partners in materials like cement, barbed wire and reinforcement bars while the rest of the required material and labour is community contribution. Once the rock catchment dam is completed there is minimum maintenance apart from cleaning the rock catchment before the rains. Occasionally desilting of the storage reservoir and maintenance of the draw off pipes would be required. The community usually organizes a management committee that is given the responsibility of overseeing the utilization of the water facility. Due to acute shortage of water, the community usually organizes people amongst themselves to manage the water source. The water users are charged a nominal fee for maintenance and repair of the facility. Construction of the storage tanks or reservoirs cannot be done without technical designs and supervision during the construction. It requires professionals with good knowledge of engineering principles to guide the community into construction. The government and development partners have assisted in the design and implementation of the water harvesting system.

6.4.5 Sand dams

Description

A sand dam is constructed by erecting a concrete or stone masonry wall on a natural rock foundation across a riverbed at a selected site. The height of the wall is exposed above the floor of the riverbed. It is constructed in stages, and the height of each stage is limited to half or one metre in order to enhance deposition of coarse sand for high water yield. Coarse sand may yield up to 35 % of extractable water, while medium and fine sand may yield 25 % and 10 % of the total volume of sand stored respectively. The dam wall is constructed on the assumption that sufficient amount of coarse sand will be eroded from the catchment and deposited at the dam. Sand dams are constructed in river catchments where the geology permits high yield of coarse sand in the process of soil formation through weathering. Sand dams are constructed across dry sandy riverbeds in arid and semi-arid lands.

Dry riverbeds also called ephemeral streambeds are seasonal water courses that transport runoff from catchment areas intermittently depending on the rainfall pattern and amount. Most of the rainwater being transported downstream in the riverbeds appears as flash floods during the rains and the flow may last only a few days after the rains. The objective of sand dam construction is to intercept and retain a portion of the runoff and utilize it for domestic, livestock or small scale irrigation. The potential sites for sand dam construction can be identified through aerial photo interpretation. Areas of high sand deposition can be easily identified in the aerial photographs. The local community can also help to identify potential sites using their knowledge of the area. In a number of cases people in the arid areas dig in the sand deposition areas in search for water. This can assist to identify suitable sites.

Sand dams are well suited in arid areas where the catchment yields large amounts of coarse sand depending on the geological formation. Large pore spaces between the sediment aggregates will increase the volume of water stored in the sand dam. Sections of the riverbed between 10 and 15 % slope would be suitable to ensure long distance of sand deposition up-stream from the dam wall. Since water is stored in the pore spaces of sand, the larger the volume of sand stored, the higher the volume of water stored. Steep sections of the riverbed will have a short throwback of sand from the dam wall. The practice has been used in a number of ASALs with more structures in Eastern province than in other areas. Many sand dams have been constructed in Machakos, Makueni, Kitui and Mwingi districts. Sand dams have also been constructed in some parts of Bondo district and in Kusa within lake Victoria Basin but the success needs to be evaluated.

This is a demand driven practice. Severe water shortage in the ASALs causes people to desperately look for any source of water. Digging in the sand along the dry riverbeds made people to think of ways of increasing the volume of water stored. With the technical assistance by the government the technology has been extended to many areas and there is still a large potential in developing the system.

A standard sand dam across a river valley of about 50 metres wide and 4 metres deed would cost between USD 7,000 -10,000 depending on site characteristics, availability of local construction materials and level of community contribution.

Benefits:

For more than 50 years, sand dams have provided water for domestic and livestock during extreme droughts when all other water sources have dried up. Several sand dams can be constructed at many sites along the watercourse and this would have a good coverage for water distribution to the community. This will reduce the distance that people and livestock walk to the water sources. There are direct and indirect benefits of sand dams. The direct benefits include increased water availability to the community, reduced walking distance to the water sources, saving time that can be used in other developments. Indirect benefit includes environmental conservation where sand dams would cause a rising in the water table within the surrounding areas that enhance vegetation establishment. When several sand dams are constructed in a watercourse, the flooding incidences in the lowlands would be reduced.

Sand dams have positive environmental impacts in places where they have been successfully implemented. There is effective soil erosion control by controlling the velocity of runoff. Riverbank erosion is minimized and the riverbanks become stable. Vegetation starts to establish because of rise in water table. There is a good example in Kola location in Machakos district.

The technology calls for high level of community participation. This makes people to work together to achieve a common goal. People are able to support each other and are able to accomplish what cannot be possible for an individual. By pulling all their resources together there is a sense of achievement when the community completes one sand dam. Apart from cement and reinforcement bars, other building materials are obtained locally thus lowering the cost of construction. This makes the technology affordable by the community.

Limitations:

The practice is not suitable in catchment areas with high percent clay and silt because of small pore volume between the aggregates. The size of dam wall is limited to the dimensions of the river valley. Narrow and deep sections of the riverbed may limit accessibility to the construction site and raise the cost of construction.

Sand dams are not suitable in any location depending on valley morphological features that may make some sites inaccessible for sand dam construction. Methods of water abstraction have not been well developed. This leaves people with the only option of digging holes in the sand dam to extract water. Water is contaminated once holes have been opened for water extraction because livestock take water from the same holes that people draw from.

Operation and maintenance:

Sand dams have been constructed as community self-help projects where the community contributes money and unskilled labour. NGOs, charitable organizations and other well-wishers have also helped in sand dam construction. The government has helped in technical advice and supervision of construction. The community manages and maintains the sand dam. Once the sand dam has been successfully constructed, there is minimum maintenance cost. The main issue is protecting the sand dam against sand harvesters who target such sites for sand mining. The sand harvesters sell the sand to the building industry mostly in urban areas. When the top layer of sand is removed, the stored water is exposed to high evaporation losses. Where sand dams have been constructed, the local community usually has a structured organization. Some people are appointed to oversee equitable utilization of the water. Some community organizations may have by-laws to protect against misuse and may instil some penalties to defaulters.

7.0 Selection Process for Best Practices in Water Harvesting (WH)

Selection process for best practices involves evaluation of salient features such as; suitability, economics, and socio-cultural acceptability, replicability to other areas and sustainability, adoption rate, technical skills required and complexity in implementation, community participation and environmental conservation. The ranking of best practices was based on the major salient features which were given a scale of 1-10 points where the highest score of 10 points refers to the best situation. Average condition was given 5 points. The lowest point referring to the worst situation was allocated 2 points. Other salient features were based on a scale of 1- 8. The best condition was given maximum score of 8 points; average condition was given 4 points while the worst situation was given 2 points (Table 4).

Table 4: Selection Criteria for Best practices

TABLE 4: SELECTION CRITERIA FOR BEST PRACTICES IN WH Salient features
Major salient features – maximum of 10 points
Sustainability (recent -2, less than 5 yrs -5, more than 5 yrs -10)
Economics (cost) (high-2, medium -5, low -10) Adoption rate (low -2, medium -5, high -10) Replicability ((low-2, medium -5, high -10) Operation and maintenance (high -2, medium -5, low -10)
Environmental impact (-ve -2, average -5, highly +ve -10)
External/Government financial support
Other salient features – maximum of 8 points
Suitability (low -2, medium -4, high -8)
Technical skills required (high -2, medium -4, low-8)
Socio-cultural acceptability (not accep -2, medium -4, highly accep-8) Complexity in construction/implementation (high -2, medium -4, low -8) Government support in policy (low -2, medium -4, high-8) Multiple use of harvested water (low -2, medium -4, high -8)
Community participation (low -2, medium -4, high -80

7.1 Prioritization and ranking of best practices in water harvesting.

Short listing and ranking of best practices was done in a matrix format in reference to the salient features describing the criteria for selection. The prioritization of best practices in runoff and in-situ water harvesting is given in Tables 5, 6 and 7 while ranking of best practices according to agro-climatic zones is given in Table 8.

Table 5: prioritization of best practices in water harvesting in agro-climatic zones i, ii and iii

Agro-climatic zones I, II and III (Humid to semi-humid). Range of annual rainfall 1000 to 2000 mm											
Salient features	Practice/technology										
Major salient features – maximum of 10 points	tr	mn	gs	bt	cod	ww	hr	cr	tp	fp	gc
Sustainability (recent -2, less than 5 yrs -5, more than 5 yrs -10)	5	10	10	10	5	5	5	10	5	5	10
Economics (cost) (high-2, medium -5, low -10)	10	5	10	5	5	5	5	5	5	5	5
Adoption rate (low -2, medium -5, high -10)	5	5	5	10	5	5	2	5	5	5	5
Replicability ((low-2, medium -5, high -10)	5	5	10	10	10	10	5	5	5	10	10
Operation and maintenance (high -2, medium -5, low -10)	10	10	10	5	5	5	5	10	5	5	5
Environmental impact (-ve -2, average -5, highly +ve -10)	5	5	5	10	5	5	5	10	5	5	5
External/Government financial support (high – 2, average – 5, low – 10)	10	10	10	10	5	5	10	10	10	5	5
Other salient features – maximum of 8 points											
Suitability (low -2, medium -4, high -8)	4	8	4	8	4	4	4	4	4	4	4
Technical skills required (high -2, medium -4, low-8)	8	8	8	4	4	4	4	8	8	4	4
Socio-cultural acceptability (not accep -2, medium -4, highly accep-8)	4	4	4	4	4	4	4	4	4	4	4
Complexity in construction/implementation (high - 2, medium - 4, low - 8)	8	8	8	4	4	4	8	8	8	4	4
Government support in policy (low - 2, medium - 4, high - 8)	8	8	8	8	8	4	4	8	8	8	8
Multiple use of harvested water (low - 2, medium - 4, high - 8)	2	2	2	8	2	2	2	2	2	4	2
Community participation (low - 2, medium - 4, high – 8)	2	2	2	4	4	4	2	2	2	4	4
Total points	86	90	96	100	70	66	65	91	76	72	75
Ranking	**5**	**4**	**2**	**1**	**9**	**11**	**10**	**3**	**6**	**8**	**7**

Key:

tr= trash lines	cr = crop residue	gc = gully control	ww = waterways
mn = manure and composting	tp = tubukiza pits	cod = cutoff drain	hr =hedgerows
gs = grass strip	fp = farm ponds	bt = bench teraace	

Table 6: prioritization of best practices in water harvesting in agro-climatic zones iv and v

Agro-climatic zones IV and V (Semi-humid to semi-arid). Range of annual rainfall 500 to 1000 mm													
Salient features	Practice/technology												
Major salient features – maximum of 10 points	ft	rc	mc	ct	rd	gc	cod	ww	se	sa	rr	wp	fp
Sustainability (recent - 2, less than 5 yrs - 5, more than 5 yrs - 10)	10	10	10	10	10	10	10	10	10	10	5	10	10
Economics (cost) (high - 2, medium - 5, low - 10)	5	5	5	5	5	2	5	2	2	5	5	5	2
Adoption rate (low -2, medium - 5, high - 10)	5	2	5	2	2	2	2	2	2	2	2	2	2
Replicability ((low - 2, medium - 5, high - 10)	10	5	5	5	5	2	2	2	5	5	5	5	5
Operation and maintenance (high - 2, medium - 5, low - 10)	5	5	5	5	5	5	5	2	5	10	5	2	5
Environmental impact (-ve - 2, average - 5, highly +ve - 10)	5	2	5	5	2	5	2	2	5	5	2	2	5
External/Government financial support (high - 2, medium - 5, low – 10)	5	5	10	5	5	5	5	5	5	5	2	5	5
Other salient features – maximum of 8 points													
Suitability (low - 2, medium - 4, high - 8)	4	2	4	4	4	4	4	4	4	8	4	4	4
Technical skills required (high - 2, medium - 4, low- 8)	4	4	4	4	4	4	4	4	4	4	4	4	4
Socio-cultural acceptability (not accep - 2, medium - 4, highly accep- 8)	4	4	4	4	2	2	2	2	2	4	2	4	4
Complexity in construction/implementation (high - 2, medium - 4, low - 8)	4	4	4	4	4	4	4	2	2	2	4	4	4
Government support in policy (low - 2, medium - 4, high- 8)	8	8	8	8	8	8	8	8	8	8	8	8	8
Multiple use of harvested water (low - 2, medium - 4, high - 8)	4	2	2	2	2	2	2	2	4	4	4	8	8
Community participation (low - 2, medium - 4, high - 8)	4	8	2	2	2	2	4	4	4	8	4	8	8
Total points	77	66	73	65	60	57	61	51	62	80	56	71	74
Ranking	**2**	**6**	**4**	**7**	**10**	**11**	**9**	**13**	**8**	**1**	**12**	**5**	**3**

Key:

fp = farm ponds	ft = fanya juu terrace	rd = retention ditch	ct = conservation tillage
se = small earth dams	mc = micro-catchment	rr = road runoff	sa = sand dam
wp = water pans	cod = cutoff drain	ww = waterway	rc = rock catchment dams
gc = gully control			

Table 7: prioritization of best practices in water harvesting in agro-climatic zones vi and vii

Agro-climatic zones VI and VII (Arid to hyper-arid). Range of annual rainfall Less than 250 mm to 500 mm												
Salient features	Practice/technology											
Major salient features – maximum of 10 points	rd	sw	mc	mac	wp	rf	se	sa	rc	gc	ww	ct
Sustainability (recent - 2, less than 5 yrs - 5, more than 5 yrs - 10)	10	10	10	10	10	5	10	10	10	10	10	5
Economics (cost) (high - 2, medium - 5, low - 10)	5	2	5	2	2	2	2	5	5	5	2	5
Adoption rate (low - 2, medium - 5, high - 10)	2	2	5	2	5	2	5	5	2	2	2	2
Replicability ((low - 2, medium - 5, high - 10)	5	2	5	5	2	2	2	2	2	5	2	2
Operation and maintenance (high -2, medium -5, low -10)	5	5	5	5	2	2	5	5	5	2	2	2
Environmental impact (-ve - 2, average - 5, highly +ve - 10)	2	2	5	5	5	2	5	5	2	5	2	5
External/Government financial support (high - 2, average - 5, low - 10)	5	5	10	5	5	5	5	5	5	5	5	10
Other salient features – maximum of 8 points												
Suitability (low - 2, medium - 4, high - 8)	4	2	4	4	4	2	2	4	2	2	2	4
Technical skills required (high - 2, medium - 4, low - 8)	4	2	4	4	4	4	4	4	4	4	4	4
Socio-cultural acceptability (not accep - 2, medium - 4, highly accep - 8)	2	4	4	4	4	2	4	8	8	4	2	4
Complexity in construction/implementation (high - 2, medium - 4, low - 8)	4	4	4	4	4	4	4	4	4	2	4	4
Government support in policy (low - 2, medium - 4, high - 8)	8	8	8	8	8	8	8	8	8	8	8	8
Multiple use of harvested water (low - 2, medium - 4, high - 8)	2	2	2	2	4	2	8	4	4	2	2	2
Community participation (low - 2, medium - 4, high – 8)	4	4	2	4	8	4	4	8	8	4	4	2
Total points	62	54	73	64	67	46	68	77	69	60	49	59
Ranking	**7**	**10**	**2**	**6**	**5**	**12**	**4**	**1**	**3**	**8**	**11**	**9**

Key:

rd = retention ditch	sa = sand dam	ww = waterway	se = small earth dam
mc = micro-catchment	rc = rock catchment	wp = water pans	rf = river flood water harvesting
mac = macro-catchment	gc = gully control	ct = conservation tillage	sw = shallow wells

Table 8: ranking of best practices in water harvesting according to agro-climatic zones

Zone I, II & III		Zone IV and V		Zone VI & VII	
Technology	Rank	Technology	Rank	Technology	Rank
Bench terraces	1	Sand dams	1	Sand dams	1
Grass strips	2	Fanya juu terraces	2	Micro-catchment	2
Crop residue	3	Farm ponds	3	Rock catchment	3
Manure/compost	4	Micro-catchments	4	Small earth dams	4
Trash lines	5	Water pans	5	Water pans	5
Tubukiza pits	6	Rock catchment dams	6	Macro-catchments	6
Gully control	7	Conservation tillage	7	Retention ditches	7
Farm ponds	8	Small earth dams	8	Gully control	8
Cutoff drain	9	Cutoff drains	9	Conservation tillage	9
Hedgerows	10	Retention ditches	10	Shallow wells	10
Waterways	11	Gully control	11	Waterways	11
		Road runoff	12	River flood water	12
		Waterways	13		

7.2 Identification and Assessment of Best Practice Sites in Water Harvesting

Best practice sites are those where particular water harvesting technologies have been successfully implemented and sustained for a long time. There has to be notable improvements in food supply to the community, positive impact on environmental conservation and improvement in the living standards of the target community. Selection process for best practice sites involved evaluation of the systems based on the salient features given in Table 9. The detail of selection is given in Table 10 while ranking of the best practice sites is given in Table 11.

Table 9: selection criteria for best practice sites for water harvesting

Salient Features
Major salient features – maximum of 10 points
Diversity of WH practices (few - 2, average - 5, many - 10)
Range of climatic conditions where applicable (limited - 2, medium - 5, wide - 10)
Impact on environment (Negative - 2, average - 5 , highly positive - 10)
Organized community leadership (absent - 2, limited - 5, highly active - 10)
Accessibility to markets (poor - 2, average - 5, good - 10)
Operation and maintenance (high – 2, Average – 5, low – 10)
Other salient features – maximum of 8 points
Capacity building of community (low -2, average -4, high -8)
Population benefiting (low - 2, medium - 4, high - 8)
Vicinity to support institutions (absent -2, average -4, high -8)
Co-operative society (absent - 2, limited - 4, highly active, - 8)
Upstream-downstream committees (absent -2, average -4, many -8)

Table 10: prioritization of best practice sites in water harvesting

Salient features for selection of best practice site	Site				
	Machakos (Utooni)	Kitui (Mutomo)	Laikipa (Naromoru)	Kiambu (Ndeiya)	Nakuru (Lare)
Major salient features – maximum of 10 points					
Diversity of WH practices (few - 2, average - 5, many - 10)	10	5	5	10	10
Range of climatic conditions where applicable (limited - 2, medium - 5, wide - 10)	5	2	5	5	10
Impact on environment (Negative - 2, average - 5 , highly positive - 10)	10	5	5	5	10
Organized community leadership (absent - 2, limited - 5, highly active - 10)	5	10	5	5	5
Accessibility to markets (poor - 2, average - 5, good - 10)	5	5	5	10	10
Operation and maintenance (high – 2, Average – 5, low – 10)	5	5	5	5	5
Other salient features – maximum of 8 points					
Capacity building of community (low -2, average -4, high -8)	4	4	4	4	4
Population benefiting (low - 2, medium - 4, high - 8)	4	2	2	2	2
Vicinity to support institutions (absent -2, average -4, high -8)	4	2	2	4	4
Co-operative society (absent - 2, limited - 4, highly active, - 8)	4	2	4	4	4
Total points	56	47	42	54	64
Ranking	**2**	**4**	**5**	**3**	**1**

Table 11: ranking of best practice sites in water harvesting

Best Practice site in water harvesting	Rank
Lare division, Nakuru district	1
Utooni sub-location, Machakos district	2
Ndeiya Karai sub-location, Kiambu district	3
Mutomo division, Kitui district	4
Naromoru division, Laikipia district	5

7.3 Description of Best Practice Site in Water Harvesting

7.3.1 Water harvesting system in Lare Division, Nakuru district

Description

Lare division is about 200km to the west of Nairobi city at an altitude of 2,234 m.a.s.l. According to 1999 population census the area had a population of 20,000 people. The area has undulating topography with slopes ranging between 5 – 20 %. The area covers four agro-ecological units (LH2, LH3, UM4 and UM 5). The average annual rainfall is between 600 and 1,000mm. The predominant soils are Andosols and Nitosols that are deep and well drained. More than 80 % of the area is under cultivation mostly with annual crops. The area experiences occasional droughts. Water scarcity for domestic, livestock and agriculture is a major constraint to development in the area. Soil erosion is a major problem during rainy periods. The area has been food insecure for many years.

There are three water harvesting systems namely; in-situ rainwater harvesting systems including terracing and grass strips, runoff water harvesting from roadside drainage, roof catchment, and farm ponds. Most houses in Lare are roofed with corrugated galvanized iron sheets that provide suitable catchment for roof water harvesting that is done at schools, churches and individual houses. The harvested water is normally used for domestic purposes. Runoff water harvesting for agricultural production through construction of farm ponds is the most prominent system in Lare. Runoff water harvesting is done by constructing farm ponds into which road runoff is directed. The farm ponds are multipurpose water conservation structures depending on the location and size. The water pond is constructed by excavating the ground to form a small reservoir.

The water harvested in the pond may last between 3 - 6 months after rains depending on the capacity of the pond and the rate of water abstraction. The main components of the pond system are the catchment area, diversion channel, de-silting chamber (silt trap), storage reservoir and finally the delivery system. The most critical design parameters considered by the farmers in Lare are length and slope of the diversion channel. Most ponds are located just off the roads to ensure shorter channel lengths. Before runoff enters the pond, there is a sedimentation chamber designed to reduce the sediment load in the runoff getting into the ponds. This reduces the frequency of de-silting the ponds and maintains the design capacity. From the pond the water is drawn using different systems; bucket and rope system, treadle pump system or a combination of the two. Farm ponds are constructed both in high and low rainfall areas.

Construction of the ponds is labour intensive and so the initial cost is high. The storage capacity of most ponds is too small to supply sufficient water throughout a long dry season that may occur. High evaporation losses are difficult to address in hot and windy climates characteristic of the area. Reduced storage capacity due to siltation is made worse by lack of efficient silt traps. Farm ponds have been constructed at different sites depending on suitability and potential for harvesting high volume of runoff. Some ponds have been constructed within the farm, on-stream and off-stream to store river water during the peak floods. In Lare there are no perennial rivers. The water courses however receive high runoff flow during the peak of rain season. Such runoff is stored in off-stream ponds for later use.

Planning:

The land users are actively involved in planning of the water harvesting system to minimize conflicts that occur by people competing for same runoff either from roadside drainage or from a public land. Educating the land users on runoff systems and expectations will give a clear understanding of the whole process. The size of household and intended use of the harvested water, topography and soil permeability should be considered in planning.

Design:

Design of the ponds is simple because it does not involve a reinforced embankment. In order to minimize evaporation losses the surface area is reduced and compensated by deepening the pond. Water abstraction methods have been progressively improved to avoid people or livestock taking water directly from the pond. There has been more investment on pumps. The ponds need to be fenced round to minimize the risk of children and livestock drowning in the deep pond.

Construction:

Construction of water ponds is labour intensive and proper tools need to be used to improve the efficiency in construction. In some cases people work together as a group to help each other and they construct ponds in rotation. Local artisans have been trained on site selection and construction techniques for successful implementation of the technology. The main expenses in construction are hand tools and labour for excavation. A medium farm pond may cost about USD 1,500.

Stakeholders and beneficiaries:

The beneficiaries are either private individuals or the local community depending on the ownership of the pond. Since farm ponds are highly labour intensive the community participation at all stages of construction gives them a sense of ownership and willingness to maintain the facility.

Benefits of farm ponds:

Since the practice was initiated 10 years ago in Lare, the level of poverty has gone down. Many farmers are able to produce enough food crops for domestic consumption and market. Farmers have also diversified in their production systems and incorporated enterprises like bee-keeping, dairy farming, vegetable production and agro-forestry. There has been high income generation and people have raised their living standards by building better houses and improvement in nutrition. Soil erosion has been minimized and land productivity has increased. This is a demand driven activity where individuals or community are actively involved in implementation.

Farm ponds have been effective in meeting the water demands for the community in a number of months between the rainy seasons. Depending on the population and water demand, a typical farm pond would keep water for between 3 - 6 months. If there is no prolonged drought, it is possible that the stored water may last the community or household to the next rain season. Farm ponds are sited close to the homesteads to increase water availability to the household. Reduced walking distance to the water sources will save time that can be used in other development activities. There is increased water supply to the community and individuals. The ponds are easily constructed because there is no demand for construction materials apart from hand tools and local labour. They can be constructed in any environment where the soil conditions are suitable for retaining much water with minimum seepage losses. The adoption of RWH in Lare has significant socio-economic and environmental impacts in the area. RWH has reduced drudgery and time spent in fetching water hence releasing the girl child to participate in other productive socio-economic activities including school attendance.

Farm ponds have positive environmental benefits through control of surface runoff, ground water table recharge from seepage, enhancing vegetation establishment in control of land degradation. Reducing the volume of surface runoff has controlled the rate of soil erosion. The ground water table recharge through seepage and deep percolation help in establishment of vegetation that has turned the area green and increased biomass production. Trees have increased availability of fuel wood which is in high demand. Trees have also helped to beautify the environment and increased availability of timber for construction of farm buildings.

There have been increased crop yields due to water harvesting, conservation and utilization within the area by control of surface runoff. This is evidenced by a rise in different food commodities harvested and sold in the local market. The vegetation in the area looks greener than it used to be 10 years ago. Milk production has gone up because of increased fodder production. Honey production is on the increase. Previously people in the area used to suffer from water borne diseases. There has been awareness creation and training on water sanitation and treatment of drinking water by a local NGO. The incidences of water borne diseases have gone down.

Operation and Maintenance:

The community or individuals are responsible for managing the pond. Siltation is the biggest problem in water ponds. Farmers have understood the need to incorporate and maintain silt traps to reduce the sediment load in the runoff entering the pond. The farmers have increased their knowledge on efficient abstraction and utilization of the harvested water.

Water User Association or User Group:

For individually owned pond, the owner has the sole responsibility of controlling water utilization and maintenance of the pond. For a community owned water pond, there is usually a management committee or elected people to oversee the utilization of the water facility. The pond can also be managed by a person hired by the community and paid a monthly allowance. The water users pay a nominal fee as agreed by the management for maintenance of the water facility. The water is used for domestic and community farming activities which include watering tree seedlings and limited fish farming.

Enabling Environment:

There are no complications in designs and the system is easily implemented by the community and private individuals. Though Lare receives unreliable rainfall, the soils and sloping topography provides suitable environment for rainwater harvesting. The water ponds in Lare are competing effectively with other sources like boreholes and the seasonal rivers. There has been government support and other NGOs and Egerton University in extension services, and training of farmers in soil and water conservation, design and implementation of the water harvesting systems. Individual people and community self-help groups have been involved in construction of farm ponds. The local community is easily trained on identifying suitable areas for farm ponds development. The government through the Ministries of Agriculture and Livestock, Egerton University and NGOs have assisted communities where large ponds have been constructed to meet high water demands.

Social/Cultural acceptability:

The practice has been accepted socially and culturally as a viable technology that has impacted positively on the lives of many people and improved the standard of living by raising crop yield.

Limitations:

Farm ponds have the problem of breeding mosquitoes and increasing the incidence of malaria outbreaks. Open ponds are risky for children and animals if not protected by fencing around. There is high risk of contamination either by the condition of the catchment or the form of water abstraction from the pond.

Scaling up:

Most of the households in Lare division have RWH ponds. The adoption of rainwater harvesting in Lare has been enhanced by numerous trainings, excursions and extension packages offered by both local and international NGOs and government institutions. The farmers who have done very well in water harvesting systems in Lare have attended trainings at Baraka Farmers Training Centre in Molo. They have also gone for organized education tours to other areas like Machakos and some parts of Western province. Most of the ponds are constructed through individual initiatives but there are a few community water ponds.

Plate 1: Water harvesting technologies

8.0 Identification And Assessment Of Best Practices In Community Managed Irrigation (Cmi)

8.1 List of Best Practices in Community Managed Irrigation (CMI)

Any irrigation system in the field is concerned with obtaining water from a source and transferring it through a conveyance system to the soil within the rooting zone of most field crops. An irrigation system consists of abstraction, conveyance, application and drainage components. Water for irrigation may be obtained from the source by either gravity or pumping. Generally pumping systems are more expensive due to high energy and maintenance costs.

Community managed irrigation includes all irrigation activities that involve small scale farmers who own and manage an individual plot or are part of a community managed scheme. Individual irrigation systems are established where farmers have direct access to water resources close to their fields. However the development of such systems is hampered by high cost and risks of on-farm investments. Community managed irrigation schemes are initiated where water sources are not immediately bordering suitable areas for agricultural development. The irrigation schemes are owned, developed and managed by communities as irrigation water user groups or individual farmers. These schemes produce for farmer subsistence and for the domestic market and also for the export market.

There are 2,500 CMI schemes covering an area of 47, 000 hectares. This accounts for 46% of the total area under irrigation where 47% of population doing irrigated agriculture is actively employed in this sector. There are high capital and labour requirements to develop such irrigation system and therefore farmers join efforts to develop the irrigation system as a group. The community may get assistance from the government, NGOs or international organizations to finance the irrigation system. About 50% of the irrigated area (106,000ha) in Kenya is under small scale irrigation. It is estimated that 15,000ha are operated by individual farmers while 35,000ha are under community managed schemes. In this study, information was obtained on 49 community managed irrigation schemes in Nyanza, Rift valley and Central provinces. Irrigation practices carried out in Kenya are categorized depending on the source of water, crops irrigated and applicable technology (see Table 12).

Table 12: 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.

Table 13: list of best practices in community managed irrigation (cmi)

	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

8.2 Identification and Assessment of Best Practices in Community Managed Irrigation

Best practice is one that gives optimum utilization of land and water resources for sustainable agricultural production and environmental management. Criteria for selection of best practices were based on systems that covered most of the following salient features. The selection of the best practice was based on evaluating the salient features on a scale of 1-10 as indicated in Table 14. The final selection of best practice was done by developing a matrix of the salient features as given in Table 15.

Table 14: prioritization of best practices in irrigation

Salient features	Practice					
	Gravity (basin)	Gravity (furrow)	Sprinkler (GFS)	Sprinkler (PFS)	Pumping (furrow)	Drip
Major salient features						
Technical design (complex - 2, medium - 5, less complex - 10)	5	5	10	2	2	5
Sustainability (hard to sustain - 2, medium - 5, highly sustainable -10)	10	10	10	5	4	5
Operation and maintenance cost (high - 2, medium - 5, low - 10)	10	10	10	5	5	5
Cost of water delivery (high - 2, medium - 5, low - 10)	5	5	10	5	5	5
Impact on environment (negative -2, average - 5, high - 10)	5	5	10	10	5	10
Water delivery efficiency (low -2, medium - 4, high - 8)	5	5	10	5	2	10
Water application efficiency (low - 2, medium - 4, high - 8)	5	5	5	5	2	10
Other salient features						
Technical skill required in maintenance (high -2, medium - 4, low - 8)	4	4	4	4	4	4
Community participation (low -2, limited - 4, high - 8)	4	4	4	4	4	4
Technical skill required in design (high - 2, medium - 4, low - 8)	8	8	8	8	8	8
Availability of spare parts (not avai - 2, fairly avail - 4, readily avail - 8)	8	8	4	4	4	8
Ease of implementation (hard - 2, medium - 4, easy - 8)	2	4	4	4	4	8
Total points	71	73	89	61	49	82
Ranking	4	3	1	5	6	2

Key:
GFS = Gravity fed sprinkler system
PFS = Pump fed sprinkler system

Table 15: ranking of best practices in community managed irrigation (cmi)

Practice/Technology	Rank
Gravity fed sprinkler system	1
Drip irrigation	2
Gravity (furrow)	3
Gravity (basin)	4
Pump fed sprinkler system	5
Pumping (furrow)	6

8.3 Identification and Assessment of Best Practice Site in CMI

The selection process for Best Practice sites for community managed irrigation was based on evaluating sites based on available information, consultation with contact persons and personal knowledge of the consultant. Ranking of the selected sites was for those sites that satisfied most of the following salient features;

i) Sustainability of water source in terms of quantity, quality, management and control
ii) Efficiency of the conveyance system
iii) Efficiency of water distribution system in the field to check whether the system within the best practice (BP) is being adequately adopted
iv) Field Water Management (Users' attitude, Organization, equity and reliability)
v) Soil properties (chemical and physical) that provide for efficient crop water use
vi) Institutional and legal framework
  - Presence and role of Water users Association (WUAs)
  - Private sector and Government/Government agencies involved in scheme management.

vii) Participatory approaches in irrigation development and management- that there should be participatory approach at all levels
viii) Improved agronomic practices (that include but not limited to nutrient management, pest and disease control)
ix) Yield per unit area and/or per unit volume of water used.
x) Harvesting technology i.e. the type of technology
xi) Post harvesting management
xii) Marketing and marketing issues
xiii) Financial management- whether there are any forms of financial managements and the issues revolving as around transparency and accountability of financial management.
xiv) Monitoring and evaluation system and review/implementation of new recommendations

The criteria for selection of best practice sites are summarised in Table 16 while prioritization of best practice sites in community managed irrigation is presented in Table 17. The ranking of best practice sites is given in Table 18.

Table 16: criteria for selection of best practice sites in community managed irrigation schemes

Salient features
Major salient features – maximum of 10 points
Technical design (not clear - 2, Average clarity - 5, clear followed & maintained - 10)
Sustainability (two –ten yrs-2, ten-twenty yrs - 5, more than twenty yrs - 10)
Co-operative society (absent -2, limited - 5, highly active, - 10)
Impact on environment (negative -2, average - 5, positive - 10)
Water productivity (kg of biomass/litre of water) (low – 2, average – 5, high – 10)
Accessibility to markets (poor -2, average - 5, good - 10)
Operation and maintenance (high -2, medium - 5, low - 10)
Dependency on external funding (high – 2, average – 5, low – 10)
Water quality (poor – 2, average – 5, good – 10)
Other salient features – maximum of 8 points
Population benefiting (low -2, medium -4, high -8)
Capacity building of community (low -2, average -4, high -8)
Water Users Association (absent -2, average -4, many -8)
Organized community leadership (absent -2, limited -4, highly active -8)
Vicinity to support institutions (absent -2, average -4, high -8)
Status of operation (poor -2, medium -4, good -8)
Ease of implementation (low -2, medium -4, good -8)
Current condition of scheme (poor -2, Average -4, Good -8)
Government support in policy and finance (low -2, medium -4, high -8)

Table 17: prioritization of best practice sites in community managed irrigation

Salient features for selection of best practice site	Site							
	Ki	Mu	Wa	Ng	Ala	As	Alu	Ab
Major salient features – maximum of 10 points								
Technical design (not clear - 2, Average clarity - 5, clear followed & maintained - 10)	10	10	5	5	5	5	5	5
Sustainability (two –ten yrs-2, ten-twenty yrs - 5, more than twenty yrs - 10)	10	10	10	10	5	10	5	5
Co-operative society (absent -2, limited - 5, highly active, - 10)	10	10	5	5	5	5	5	5
Impact on environment (negative -2, average - 5, positive - 10)	10	10	5	5	5	5	5	5
Water productivity (kg of biomass/litre of water) (low – 2, average – 5, high – 10)	5	10	5	5	5	5	5	5
Accessibility to markets (poor -2, average - 5, good - 10)	10	10	2	5	10	2	5	2
Operation and maintenance (high -2, medium - 5, low - 10)	10	10	5	5	5	5	5	5
Dependency on external funding (high – 2, average – 5, low – 10)	10	10	5	5	5	5	5	5
Water quality (poor – 2, average – 5, good – 10)	10	10	5	5	5	5	5	5
Other salient features – maximum of 8 points								
Population benefiting (low - 2, medium - 4, high - 8)	4	4	4	4	4	4	4	4
Capacity building of community (low - 2, average - 4, high - 8)	8	8	4	4	4	4	4	4
Water Users Association (absent - 2, average - 4, many - 8)	2	4	2	2	4	4	4	4
Organized community leadership (absent - 2, limited - 4, highly active - 8)	8	8	4	4	8	8	8	8
Vicinity to support institutions (absent - 2, average - 4, high - 8)	4	4	4	4	4	4	4	4
Status of operation (poor -2, medium - 4, good - 8)	8	8	4	4	4	4	4	4
Ease of implementation (low - 2, medium - 4, good - 8)	4	4	4	4	4	4	4	4
Current condition of scheme (poor - 2, Average - 4, Good - 8)	4	4	4	4	4	4	4	4
Government support in policy and finance (low - 2, medium - 4, high - 8)	4	4	4	4	4	4	4	4
Total points	131	138	81	88	94	91	89	80
Ranking	2	1	7	6	3	4	5	8

Key:

Ki	= Kibirigwi	Ng	= Ngura	Wa	= Wahambla	Alu	= Alungo
Mu	= Mitunguu	Ala	= Alaranyahoda	As	= Asunda	Ab	= Abwao

Table 18: ranking of best practice sites in community managed irrigation (cmi)

Best Practice site CMI	Rank
Communiy managed small scale irrigation (CMI)	
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

8.4Description of Best Practice Site in Community Managed Irrigation - Kibirigwi Irrigation Scheme in Kirinyaga District

Description

Kibirigwi Irrigation Scheme is located 70 km north of Thika town along Karatina-Sagana road in Kiina location, Ndia Division, Kirinyaga district in central province (GPS co-ordinates: S 00º 33' 46.3" E 037º 11' 17.4") at an altitude of 1,026 m.a.s.l. Beneficiaries of the scheme include 277 households according to original plan but this number has more than tripled to date. The scheme is in a lowland area with gently sloping to relatively flat topography. The area is in agro-ecological zone LH3 which is classified as humid with average annual rainfall of 1,900 mm. The soils are clay loam and are relatively deep. The source of irrigation water is from Ragati River, which is a tributary of Sagana River. The area under irrigation is 110 ha. The irrigation practice is low pressure, gravity sprinkler system with a main delivery pipe that conveys water from the river to the farms. Water distribution is arranged on demand according to the cropping pattern. The major crop is French beans and the average farm size is 0.4 ha. The scheme is jointly managed between government of Kenya and farmers through Kibirigwi Farmers' Co-operative Society.

Kibirigwi Irrigation Scheme was started jointly by Ministry of Agriculture (MOA) and Tana and Athi River Development Authority (TARDA) in 1975 and implemented between 1977 and 1980. The first crop was irrigated in 1980. The project was co-funded by Kenya government and Netherlands Technical Co-operation aid at a cost of KShs. 12 million. The objective was to establish commercial vegetable production under irrigation with an ultimate target of 240 ha to be cultivated annually, establishment of a proper managed co-operative society, establishment of a system of water distribution and methods of operation and maintenance of the irrigation system, implement soil conservation programme within the wider catchment, develop a method of cost recovery and maintain a sustainable farm income and to strengthen the co-operative society to take over the running of the irrigation scheme.

Feasibility studies were done by Kenya and Netherlands governments which indicated the potential of using gravity sprinkler irrigation system in Kibirigwi. Initially the area was under grazing. There used to be a cultural belief that the area was not suitable for farming and was reserved only for grazing. The system was initially designed for 277 households but is currently serving 377 farm users and 147 domestic users. The system consists of: Headwork-weir and intake box, settling tanks, 8.65 km main line of 12", 10", 8" and 6" diameter towards the end. There are 25 lateral take-off lines, 243 hydrants, 104 field hydrants and 150 pressure regulators to ensure proper working pressure of 2.5 atmospheres at the sprinklers. Each farmer was given 2 sprinklers, detachable for shifting to other sprinkler positions with a capacity to irrigate 0.4 ha for 7 days. One sprinkler has an output of $1m^3$ per hour which equals to 4.5mm of rain per hour at sprinkler spacing of 12 x 18m.

The system can be easily adopted in any other area with similar site characteristics like Kibirigwi. A group of farmers have organized themselves and initiated such a scheme along Sagana River. There are two other similar small irrigation schemes, one near the foot slopes of Mount Kenya and another one called Mitunguu Irrigation Scheme in Meru Central District.

Benefits:

The objectives of the scheme have been met by producing an average of 10 tons of French beans per ha. In the year 2005 the total production of French beans was 300,000 kg worth Ksh. 9 million. The water is also used for domestic and livestock in addition to irrigation. During the rains the water demand is low. The beneficiaries pay an operation and maintenance fee of Kenya shillings 1,200 per year to the co-operative society for water supply. The farmers have to meet all the other production costs of ploughing, seed, fertilizer, labour for all operations and maintenance of the system in their farms. The initial project design had a component of soil conservation within the wider catchment of the area. Terracing has been done and also agro-forestry that has modified the landscape. The contract farming for French bean production by a processing company in Nairobi creates market for the produce.

Operation and Maintenance:

The co-operative society and the farmers are involved in operation and maintenance. The main activities are repairing and servicing all the components along the main line and lateral take-off lines. However due to the age of the project there have been faults in pressure regulators mainly along the lateral take offs, leading to unbalanced pressure and hence low water use efficiency. Pipe bursts are frequent during rainy season that need repair. At this period water demand is usually low and thus creating high pressure along the line. Other components requiring repair works are sluice valves, broken sprinklers and worn out threads. Involvement of farmers' co-operative society in day to day running of the scheme has sustained the scheme for many years. Capacity building of farmers in best practices on irrigation water management has been going on under the leadership of the Ministry of Agriculture extension staff. Regular monitoring and evaluation of the scheme activities is carried out by the management team. There has been good marketing strategy to ensure sustainability and high economic returns on investment.

Water User Association:

Water Users Association (WUA) was formed but has not been operational. The problem was that about 70% of the officials of the co-operative society were the same officials of the WUA. The association is at the moment dormant but with the current water sector reforms in Kenya it is hoped that the association will be revived and start operating according to the legal requirements in the water act.

Stakeholders and beneficiaries:

The government initiated the project with the assistance of the Netherlands government. Ministries of agriculture and co-operative development act on behalf of the government. The community through the co-operative society and the company that contracts the farmers to grow French beans are also key stakeholders.

Enabling Environment:

The scheme was initially developed by Kenya government and is within the policy of irrigation development in Kenya.

Training and extension support:

There has been continuous capacity building to farmers and their leaders by the Ministry of Agriculture, Ministry of Co-operative Development and other NGOs.

Social/Cultural acceptability:

The original cultural belief that the area was not suitable for farming has changed over the years. People have accepted that Kibirigwi Irrigation Scheme is a nucleus of economic development of the area.

Limitations:

There are some farmers who do not make prompt payment for operation and maintenance costs. The standard of management of the farmers' co-operative society is low. The WUA has not been strengthened. The cost of maintaining the system is not high but the management is rather poor. The system of cost recovery from the farmers is inefficient and as such the maintenance of the basic infrastructure is poor. There are many farmers who default in payment for water supply services and that means a loss of revenue to the society.

Scaling up:

The success of Kibirigwi Irrigation Scheme has led to establishment of two other small scale community managed irrigation schemes within the same region. The reason for considering the scheme as a successful best practice is because the area has good potential for horticultural production and good marketing strategy.

Lessons learned:

Planning:

Involvement of all stakeholders in the project area through consultations, co-ordination and communication has sustained the productivity of the scheme.

Design:

The scheme operation is below the design capacity due to inadequate water and poor maintenance strategy.

Construction:

Use of locally available materials and trained personnel in the fields of engineering, quantity survey has reduced the overhead cost of operations.

Implementation:

Use of technically qualified people in construction and maintenance of the irrigation facilities and agronomic practices has helped in maintaining high crop yield that has been sustained for more than ten years.

Operation and Maintenance:

Operations and maintenance has involved training of farmers and cooperative society members on operation, control and maintenance of irrigation facilities, routine repair of pipelines and sprinklers. Strengthening the WUA and co-operative society and having regular meetings with all stakeholders would increase the level of maintenance.

Beneficiaries' involvement:

Beneficiaries have been actively involved in decision making and day to day running of the project through their elected leaders. This has raised their sense of ownership of the scheme for sustainability.

Realization of benefits:

Production of French beans under contract with a food processing firm in Nairobi has assured the farmers of ready market and this has been very profitable. There is a lot of money exchange amongst the people in Kibirigwi as a result of good market price for the French beans and other produce. New buildings and diverse businesses have been established in Kibirigwi town for the last 10 years. There has been major transformation of the lives of the people because of the scheme.

Other Remarks or observations:

Despite the management problems that have existed for long, Kibirigwi Irrigation Scheme has become sustainable because of market assurance and prompt payment to the farmers. There is increased participation of farmers in day to day running of the scheme through the co-operative society. There is more room to investigate ways of increasing water use efficiency.

9.0 Public Managed Irrigation Schemes

These are larger investments than community managed irrigation schemes. The management of these schemes is complex because they involve large communities and high crop output that requires high level marketing strategies. Water distribution, operation and maintenance require organized systems to minimize conflicts amongst stakeholders. Public irrigation schemes are developed and managed by public agencies like National Irrigation Board (NIB) and Regional Development Authorities (RDAS). Over 90 % of Kenya's rice is produced in NIB schemes which account for 12 % of the irrigated land.

Private irrigation schemes are commercial and operate at high level of technology. They mainly produce high value crops for export market. The schemes cover 42 % of the land under irrigation. The operations of private irrigation schemes were not covered in detail in this study due to time limit. The private schemes do not easily release data and information on their operations and therefore would require more time to organize for visits and data collection.

In this study, information was obtained on 7 public irrigation schemes in the Lake Basin, Rift Valley, Central and Coast provinces (annexes 7, 8, and 9). The prioritization of the best practice site is given in Table 19. The prioritization was based on evaluating the major salient features which were assessed on a scale of 1-10. The best situation was given a maximum of 10 points. Average situation was given 5 points and the worst situation was given 2 points. Other salient features were evaluated on a scale of 1-8. The best situation was given a maximum of 8 points, while the average and worst situations were given 4 and 2 points respectively. The highest number of points constituted the best practice site. The ranking of best practice site is given in Table 20.

Table 19: Prioritization of best practice sites in public managed irrigation (pmi)

Salient features for selection of best practice site	Site						
	West Kano	Ahe	Bunya	Perker	Mwe	Bura	Hola
Major salient features – maximum of 10 points							
Technical design (not clear - 2, Average clarity - 5, clear followed & maintained - 10)	5	5	2	10	10	5	2
Sustainability (two –ten yrs-2, ten-twenty yrs - 5, more than twenty yrs - 10)	5	5	5	10	10	5	5
Co-operative society (absent -2, limited - 5, highly active, - 10)	2	2	2	10	10	2	2
Impact on environment (negative -2, average - 5, positive - 10)	2	2	2	10	10	2	2
Water productivity (kg of biomass/litre of water) (low – 2, average – 5, high – 10)	2	2	2	5	5	2	2
Accessibility to markets (poor -2, average - 5, good - 10)	5	5	2	10	10	2	2
Operation and maintenance (high -2, medium - 5, low - 10)	2	2	2	10	10	2	2
Dependency on external funding (high – 2, average – 5, low – 10)	2	2	2	10	10	2	2
Water quality (poor – 2, average – 5, good – 10)	2	2	2	10	10	2	2
Other salient features – maximum of 8 points							
Population benefiting (low - 2, medium - 4, high - 8)	4	4	2	8	8	2	2
Capacity building of community (low - 2, average - 4, high - 8)	4	4	2	4	8	2	2
Water Users Association (absent - 2, average - 4, many - 8)	2	2	2	8	8	4	2
Organized community leadership (absent - 2, limited - 4, highly active - 8)	4	4	4	8	8	4	2
Vicinity to support institutions (absent - 2, average - 4, high - 8)	2	2	2	4	4	2	2
Status of operation (poor - 2, medium - 4, good - 8)	4	4	4	4	4	4	2
Ease of implementation (low - 2, medium - 4, good - 8)	2	2	2	4	4	4	2
Current condition of scheme (poor - 2, Average - 4, Good - 8)	4	2	2	4	4	4	2
Government support in policy and finance (low - 2, medium - 4, high - 8)	2	2	2	8	8	4	2
Total points	57	53	73	137	141	54	39
Ranking	4	6	3	2	1	5	7

Key:

Ahe	= Ahero	Perker	= Perkera
Bunya	= Bunyala	Mwe	= Mwea

Table 20: ranking of best practice sites in public managed irrigation (pmi)

Best Practice site P/PMI schemes	Rank
Mwea (Kirinyaga district)	1
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

9.1 Description of Best Practice Site in Public Managed Irrigation - Mwea Irrigation Scheme

Description

Mwea Irrigation Scheme is located 90 km north east of Nairobi (GPS co-ordinates: S 00º 42' 23.3'' E 37º 19' 53.2") at an altitude of 1,158 m.a.s.l. The scheme is situated in gently sloping lowland area with most of the land on relatively flat topography. The area is characterized as semi-arid area and receives average annual rainfall of 900mm. The soils are vertisols (black cotton soils) and the main activity is paddy rice production. The original tenants were 4,000 people with an average farm size 1.6 ha.

The source of irrigation water is from two perennial rivers (Thiba and Nyamindi) that flow from Mt. Kenya catchment giving reliable water supply. The irrigated area is 7,500 ha. Water delivery system is by gravity, open channel both lined and unlined canals that deliver water to level basins. Water distribution is arranged on demand according to the cropping pattern. The main irrigation fields are planted with rice but some farmers also use the same water to grow a number of horticultural crops. The scheme is jointly managed between the Government of Kenya and the farmers' co-operative society.

Mwea Irrigation Scheme was started in 1956 by African Land Development (ALDEF) Programme. The scheme was started by detainees during the struggle for independence. The scheme development has been in stages and the gazetted area is 30,350 acres (12,140 ha). A total area of 16,000 acres (6,400 ha) have been developed for paddy rice production. The water is abstracted from the rivers by construction of weirs and distributed by gravity through major, secondary and tertiary canals. The canals are both lined and unlined depending on seepage losses and micro-relief of the area. Marketing of rice was initially done by National Irrigation Board (NIB) on behalf of the farmers. This has changed and the farmers are responsible for marketing their rice through the co-operative society.

The development of the scheme involved a number of surveys such as; hydrological including river discharge and water quality, land use, soil, land use practices, soil genesis, mechanical, physical and chemical properties of the soil, land capability including suitable crops, farm economic and marketing survey, topographical survey, meteorological survey including data on rainfall, temperature, relative humidity, evapotranspiration and wind speed.

Benefits:

The objective of the scheme has been met by producing more than 25,600 tonnes of paddy rice per year. The irrigation water is also used for domestic and livestock purposes. During the off-season of rice production, the water is used in horticultural farming. Basin irrigation helps in ground water recharge and there is good impact on the environmental conservation.

Stakeholders and beneficiaries:

The government initiated the project. There was assistance by the Japanese government in improvement of water distribution system through renovation of intakes, canals and division boxes. Farmers are the major beneficiaries and contribute more than 80% of the scheme operations. The stakeholders include NIB, Japanese Government, Farmers co-operative society and rice millers.

Operation and Maintenance arrangements:

The National Irrigation Board (NIB) manages and maintains the water distribution system at the intake and major canals. The farmers manage and maintain the branch canals and the line canals to the farms. The farmers pay operation and maintenance costs of Ksh. 2,000 per annum to NIB. The payment is over 90% of the expected amount per year. The farmers have to meet all the other production costs of ploughing, seed, fertilizer and labour for all operations. The government assists in provision of heavy machinery and vehicle for operations. If the payment of service charge is 100% by all land users through Water Users Association, the scheme operations can be sustained for a long time without requiring external financial assistance. There has been continuous capacity building to farmers and their leaders. The government through NIB has been assisting in training community leaders in operation and maintenance.

Water User Association or User Group:

Water Users Association is very active in irrigation water management at Mwea. The scheme is divided into eleven major units according to the major canals. The farmers elect one leader per unit to form an apex body of 11 people. The apex body and NIB form water management committees which distribute irrigation water. There are unit leaders of branch canals and line leaders who manage the water distribution to the farms. The system has been working well.

Reason for choice as Best Practices site:

The irrigation scheme was chosen as best practices site because of good data management on river and canal discharge. Involvement of water users association in day to day running of the scheme has improved on the maintenance of the scheme. Capacity building of farmers in best practices on irrigation water management has continued by the direction of NIB staff. Monitoring and evaluation of scheme activities is carried out on regular basis.

Limitations:

The system does not do well in red soil or sandy soil with high infiltration rate and where land is in a steep area. Expansion of irrigated area is restricted by inadequate water supply. Non payment of operation and maintenance fee by some farmers creates difficulties in sustainability of the system.

Lessons learnt:

Planning:

There is good co-ordination amongst all stakeholders in the project through consultations, meetings and communication.

Design:

There are two major extension areas already being implemented covering 1,200 ha. The Government of Kenya is assisting in construction of water channels and water control gates. The scheme activities are followed according to the design.

Construction:

Use of trained personnel in the fields of engineering, quantity survey, material engineer, economists, agronomists and sociologists in construction and maintenance has helped to improve the performance of the scheme.

Operation and Maintenance:

Training of staff members on operation, control and maintenance of irrigation facilities and production processes ensure sustainability of the irrigation system. Routine and preventive operation and maintenance are embraced rather than dealing with curative measures.

Beneficiary involvement:

Beneficiaries should be actively involved in decision making and day to day running of the project through their elected leaders. This will raise their sense of ownership of the scheme for sustainability.

Realization of benefits:

Strengthening the management of farmers' co-operative society has improved their bargaining power in marketing and accessibility to credit.

Other Remarks or observations:

To achieve the best practice, you require regular consultation, co-ordination and communication amongst all stakeholders.

9.2 Description of Best Practice Site in Public Managed Irrigation - Perkera Irrigation Scheme

Description:

Perkera Irrigation Scheme is located 100 km north of Nakuru town near Marigat Township in Baringo district (GPS co-ordinates: S 00º 28' 11.1" E 035º 58' 51.3") at an elevation of 1,036 metres a.s.l. It is within the semi-arid area in agro-ecological zone LM5 and receives average annual rainfall of 600mm. The soils are deep silt cay. The irrigation scheme is situated in very gently sloping to flat topography. The beneficiaries of the scheme include 672 households and the average farm size is 1.6ha. Due to the nature of soils, riverbank erosion is a major problem.

The source of irrigation water is Perkera River which is perennial but the flow fluctuates with very critical low flows between the months of August and March. The total area developed for irrigation is 810ha out of which 500ha is cropped per season. The method of water abstraction and conveyance is by gravity through the main canal and secondary canals to the irrigated fields through furrow system. The canals are mostly unlined and water application is arranged on demand according to the cropping pattern. The main crop is seed maize but other horticultural crops are also grown during the off season for seed maize. The scheme is managed jointly between the Government of Kenya through NBI and farmers through Water Users Association.

Perkera Irrigation Scheme was started in 1954 by political detainees who provided labour for construction. The first crop of onions was planted in 1956 on 567ha. The potential area for irrigation is 2,348ha. In the early 1960's 120ha was added to the already cultivated area but was abandoned after one season when it was realized that irrigation water was not enough to cater for all the area developed. At present the total area developed for furrow irrigation is 810ha out of which only 500ha is cropped per season. Initially the scheme was a major source of bulbed onions, dried chillies and watermelon. Other crops included pawpaw and cotton. Farmers abandoned production of the above crops due to marketing problems. In 1996 farmers started growing seed maize under contract agreement with Kenya Seed Company. Up to now, this is the major crop in the scheme since 1996. The feasibility studies carried out in the area showed that the Jemps flats were suitable for irrigation. The last study was done in 1936 but due to financial constraints construction was not started until 1954 when political detainees provided labour for construction. The study included hydrological survey involving data collection and analysis on river discharge and water quality of Perkera River.

Benefits:

The objectives of the scheme have been met by producing an average of 2.5 million kg of seed maize with a gross value of Kshs. 80.0 million of which a total net of Ksh. 60.0 million was paid to the farmers. The water is also used for domestic and livestock. During the off-season of seed maize production, the water is used in horticultural farming. The beneficiaries have been actively involved in decision making and day to day running of the project through their elected leaders. This has raised the farmers' sense of ownership of the scheme for sustainability. Furrow irrigation helps in ground water recharge which helps in improving the environment. Vegetation remains healthy and green throughout the year when in other areas outside the scheme the vegetation is water stressed and has low biomass production.

Stakeholders and beneficiaries:

The government initiated the project which was later put under the management of National Irrigation Board. There has been assistance by other organizations such as Kenya Seed Company in marketing of seed maize. Teachers Saving and Credit Co-operative Society (SACCO) has also assisted in provision of credit for input supply.

Realization of benefits:

Production of seed maize has been very profitable. There is a lot of money exchange amongst the people in Marigat as a result of good market price for the seed maize. New buildings and diverse businesses have been established in Marigat town for the last 10 years. There has been major transformation of the lives of the people because of the scheme.

Operation and Maintenance arrangements:

The National Irrigation Board (NIB) manages and maintains water distribution system at the intake and major canals. The farmers manage and maintain the branch canals and the line canals to the farms. NIB signs the contract agreement with Kenya Seed Company on behalf of the farmers. NIB is in charge of handling marketing of seed maize. The payments for seed delivery are made to the farmers through NIB. The Water Users Association committee on behalf of the farmers' co-operative society works with NIB in sorting out the payments to the farmers. The production costs credited to the farmers are recovered from their sale of seed maize. There has been continuous capacity building to the farmers and their leaders by NIB and other stakeholders. The government through NIB has been assisting in training community leaders in operation and maintenance. The beneficiaries pay operation and maintenance cost to NIB for irrigation water supply of Kenya shillings 2,000 per year. The farmers have to meet all the other production costs of ploughing, seed, fertilizer and labour. If all the beneficiaries would pay the operation and maintenance fee through the Water Users Association, the scheme operations can be sustained without any problem.

Water User Association or User Group:

Water Users Association (WUA) is very active in irrigation water management. The elected leaders of the association are members of the planning committee that oversees the activities of the scheme on behalf of the farmers.

Social/Cultural acceptability:

There are two major groups of people in Marigat: pastoralists and agro-pastoralists. The pastoralists occasionally graze their livestock in the irrigated fields and in the process destroy the crops and damage canals. This is a major conflict that makes irrigation farming difficult. However the conflicts are resolved by the community leaders. Apart from this the scheme has been accepted by all people as a major economic base in the area.

Limitations:

Some farmers default on payment of operation and maintenance fees to the NIB. The management level of the farmers' co-operative society is low and Kenya Seed Company has no confidence with the society's management. For this reason the Kenya Seed Company signs contract agreement with NIB. This means that if NIB hands over the scheme management to the farmers' society, there can be problems in marketing and hence sustainability of the scheme.

Scaling Up:

The success of Perkera Irrigation Scheme has led to establishment of two other small scale community managed irrigation schemes namely Eldume along Waseges river that drains from Ndondori catchment through Subukia to Lake Bogoria and Sandai Irrigation Scheme along Molo river that is a tributary of Perkera river. Each of the two schemes covers an area of 120ha.

Reason for choosing Perkera as Best Practice site:

The scheme has good data management on river and canal discharge. Involvement of water users association in day to day running of the scheme has improved the scheme management for sustainability. Through capacity building of farmers in best practices on irrigation water management, the farmers have gained management skills. There is regular monitoring and evaluation of scheme activities and good data management. There is good marketing strategy by involving a contractual agreement that ensures sustainability. There is good co-ordination amongst all stakeholders and an adequate system of conflict resolution between the pastoralists and the farmers.

Lessons learnt:

Planning:

Involvement of all stakeholders in the project area through consultations, co-ordination and communication has increased efficiency of scheme management.

Design:

The scheme operation is below the design capacity due to inadequate water supply.

Construction:

Use of skilled manpower and well trained personnel in the fields of engineering, quantity survey, irrigation and agronomy has sustained productivity of the scheme.

Operation and maintenance:

Training of WUAS on operation, control and maintenance of irrigation facilities and production processes by NBI staff has been going on for a long time. There is much emphasis on routine cleaning and repair of canals and intake. Regular meetings with WUAS leaders and NIB staff have strengthened the management of the scheme.

Other Remarks or observations:

Despite the inadequate water supply, Perkera Irrigation Scheme has been sustainable for many years because of market assurance and prompt payment to the farmers. This has come about due to sustained seed production through signing contract agreement between NIB on behalf of the land users and Kenya Seed Company. The scheme has also been sustainable through participation of farmers in day to day running of the scheme through the various organizations, steering committee, Water User Association, advisory committee and the co-operative society.

10.0 Field Verification

The time allowed for field work in this study was limited to 3 days according to the contract document. In order to maximize on the time allowed, selection of sites was done such that there would be more than one site to visit in any direction. The first two sites included Kibirigwi (CMI) scheme and Mwea (PMI) scheme in Central province. The second two sites included water harvesting (WH) system in Lare division and Perkera (PMI) scheme in Rift Valley province. The choice of two public managed irrigation schemes was based on diversity of crops grown, irrigation system and marketing strategies. The detailed description of the four sites is given in the text but the following is a brief summary:

10.1 Kibirigwi (CMI) scheme

The scheme has transformed the livelihood of people living in the area. The income generated from the sale of produce has improved the local economy which is evidenced by the developments within the local town. Many new buildings have been constructed in the last 10 years. The growth of the economy has been due to the production activities in the scheme. The contract agreement between the co-operative society and the food processing firm in Nairobi assures the farmers of regular cash income from the sale of produce. There is a registered water users association but currently it is dormant. Irrigation management activities are done by the co-operative society under the direction of the Ministries of Agriculture and Co-operative Development.

10.2 Mwea (Public Irrigation) scheme

This was found to be a very well organized scheme. There is a strong co-operative society that deals with post-harvest handling of rice, processing and marketing. There is also a strong water users association that manages water allocation to the farms under the guidance of National Irrigation Board staff. The main crop is paddy rice that is sold through open market system. Due to high demand for rice, farmers are able to sell the entire surplus after meeting their own demand for consumption. The farmers are able to get regular income from the sale of rice.

10.3 Lare (WH) site

This is a dry area that previously did not produce enough food for the population. The water harvesting interventions through farm ponds, road runoff harvesting and micro-irrigation and terracing has transformed the area and many farmers are able to produce enough for home consumption and the surplus sold in the local market. The interventions have also improved the environment that is evidenced by thriving green vegetation during the dry periods. This has been attributed to the recharge of ground water table that favours vegetation growth and especially where there are agro-forestry components.

10.4 Perkera (Public Irrigation) scheme

At Perkera the marketing system is through signing contract agreement for production and sale of seed maize. This has made the farmers to have a regular income because of assured market. The income from the sale of produce has improved the local economy. For the last 10 years, Marigat town has experienced tremendous growth in buildings, infrastructure and other trading operations which are all related to the activities of Perkera Irrigation Scheme.

11.0 Review Of Existing Water Harvesting And Irrigation Guidelines

A number of existing manuals and guidelines were reviewed and the following is a summary of information obtained.

11.1 Hai, M.T. 1998: Water Harvesting - An illustrative manual for development of micro-catchment techniques for crop production in dry areas.

The manual is widely used by the Ministry of Agriculture extension staff and also for teaching at agricultural colleges and Universities. The manual is based on applied research done by the author in one of the arid areas in Kenya (Kitui district). There are good illustrations of different types of water harvesting techniques. Design principles and procedures of constructing different water harvesting structures are well explained and easy to understand. The manual is still relevant and useful in addressing the needs for harvesting water for improved crop yield in the ASAL.

Gaps:. No gaps in the manual

11.2 Stephen, N. Ngigi 2003: Rainwater Harvesting for improved food security: Promising Technologies in the Greater Horn of Africa. Kenya Rainwater Association, Nairobi.

The manual was based on case studies done in the East African region (Kenya, Uganda, Tanzania and Ethiopia) under a project sponsored by USAI. The project was implemented through Kenya Rainwater Association. The manual gives documentation of various rainwater harvesting technologies carried out in the four countries. The technologies in the manual can be replicated in other areas of similar environments. The manual gives analysis of the factors affecting promotion and adoption of rainwater harvesting technologies.

Gaps: There is no uniformity in systematic economic analysis of the documented technologies. The returns on investment need to be investigated for all the technologies for the purpose of giving people a choice of technology to suit their capability.

11.3 Wagner, B. (editor) 2005: Water from ponds, pans and dams. Technical Hand book No 32. World Agro-forestry centre, Nairobi.

The manual gives details of project identification, planning, design and construction, operation and maintenance of runoff water harvesting systems. It gives economic analysis showing the benefits of the different systems. There are illustration diagrams and photographs that make it easy to understand the manual.

Gaps: No gaps noted

11.4 Kaumbutho, P and Kienzel, J. (editors) 2007: Conservation agriculture as practiced in Kenya: Two case studies.

The publication gives information on two case studies done in Laikipia and Siaya districts. The studies were done with ox-drawn implements in small scale farms. The results show the benefits of conservation tillage by increasing crop yield.

Gaps: There are missing links between farmers and service providers. Government policies to guide collaborators and stakeholders on conservation agriculture are not clear. Conservation agriculture equipments were not adequate. Local manufacturers or artisans and suppliers did not stock equipments for farmers to buy.

11.5 Maimbo, M., Khaka, E., Mati, B., Oduor, A.R., Tanguy, D.B., Nyabenge, M. and Oduor, V. 2007: Mapping the potential of Rainwater Harvesting Technologies in Africa: A GIS overview on development domains for the continent and nine selected countries. Technical Manual no 7. UNEP and World Agro-forestry Centre, Nairobi.

The manual gives an overview of water scarcity situation in the African region. Suggestions are given on water harvesting alternatives for different regions.

Gaps: The information cannot be used for detailed planning since the study was basically an overview. However it can be used to assess the potential of different regions for more detailed planning.

11.6 Maimbo, M., Sang, J.K., Odhiambo, O.J., Oduor, A.R. and Nyambenge, M. 2006. Rainwater Harvesting Innovations in response to water scarcity: The Lare experience. Technical Manual no. 5. World Agro-forestry Centre, Nairobi.

The manual gives a detailed analysis of water harvesting system in Lare division in Nakuru district. The manual gives a very high rate of adoption of rainwater harvesting ponds.

11.7 Peterson, E.N. 2006: Water from dry riverbeds.

The manual gives detailed information on construction of sand dams for water harvesting in dry riverbeds in the ASALs. It is a well illustrated manual with diagrams and photographs that make it easy to understand the design and construction of sand dams.

11.8 Peterson, E.N. 2006: Water from Rock outcrops

The manual gives detailed information on rock catchment dams. The diagrams and photographs make it easy to understand the design and construction of rock catchment dams.

11.9 Sijali, I.V. 2001: Drip irrigation options for smallholder farmers in Eastern and Southern Africa. Technical Handbook no. 24, Regional Land Management Unit (RELMA), Nairobi.

The publication covers the basic principles of soil-water plant relationships and historical perspective of drip irrigation.

11.10 Kenya Agricultural Research Institute (KARI): Drip Irrigation and Crop Management manual.

The manual covers drip irrigation systems and maintenance, agronomic aspects, environmental considerations and socio-economics of drip irrigation.

11.11 Ministry of Water and Irrigation. 2007: Final Draft Policy Paper: Irrigation and Drainage Development.

This is a policy document that has been formulated to give guidance on policy issues on irrigation development. It is hoped that once the policy document is passed into law, there will be more advocacy on irrigation development.

12. Potential Institutions for Capacity Building and Twining Activities

The resource persons consulted have identified the potential institutions for capacity building as listed in Table 21.

Table 21: Potential Institutions for Capacity Building and Twining Activities

	Name of institution	Strength in relation to the needs of EWUAP	Contact address/telephone
1	Jomo Kenyatta University of Agriculture and Technology	Well trained manpower in research and extension	067 52029
2	University of Nairobi	Well trained manpower in research and extension	P.O. Box 30197 Nairobi
3	Egerton University	Well trained manpower in research. Active participation in planning and implementation of Lare water harvesting project	P.O Box 536 – 20115 Egerton
4	Maseno University	Well trained manpower in research and extension and also situated within the Nile Basin.	P.O. Box 333 - 40105 Maseno
5	Kenya Rainwater Association	Experience in water harvesting and small scale irrigation. Good organizational skills in training and conferences/workshops	020 10742 Nairobi
6	Kenya Agricultural Research Institute (Irrigation and Drainage Branch)	Well trained manpower in research and extension. Actively involved in irrigation research and development. Have developed irrigation operational manuals including drip irrigation.	P.O Box 57811 Nairobi
7	Ministry of Water and Irrigation	Trained manpower. Mandated to deal with technical and policy issues in irrigation development.	Box, 30521, Nairobi
8	Ministry of Agriculture (Land Development Division)	Well training staff. Well established extension service that would make to implement water harvesting and irrigation projects	020 30028, Nairobi
9	Kenya Meteorological Training Institute	Good training facilities and national data base on rainfall amount and distribution.	P.o Box 30259 Nairobi
10	Regional Development Authorities • LBDA • KVDA	Have been implementing regional development projects where irrigation and water harvesting are important components of development.	LBDA P.O Box 1516 Kisumu. KVDA P.o Box 68258 Nairobi.

	• CDA • TARDA • ENSDA • ENNDA		CDA P.o Box 213 Mombasa. TARDA P.o Box 47309 Nairobi. ENSDA P.o Box 213 Narok. ENNDA P.o Box 203 Isiolo.
11	National Irrigation Board (NIB)	Well trained personnel in irrigation development. In charge of most of the Public managed irrigation schemes	P.o Box 30372 Nairobi
12	Kenya Water Institute	Training and research	Box 60013 Nairobi
13	National Environmental Management Authority (NEMA)	Mandated to implement environmental laws against pollution and degradation, Environmental impact assessment on irrigation projects.	
14	International Centre for Research in Agroforestry (ICRAF)	Applied field based research in partnership with farmers	Box 30677 Nairobi

13. Impact Of Best Practices On Overall Efficiency Of Water Use

There has been more focus in provision of water for different uses but the efficiency of different systems has not been adequately evaluated. During the study it was difficult to get information from the resource people on how much produce was expected from $1m^3$ of irrigation water used. The efficiency of water use could not be quantified during this study. Such information can only be obtained through research and demonstration which can be incorporated in EWUAP as an important component. This can be easily done in collaboration with Universities and research institutions. There is need to establish critical periods of irrigation requirements for different crops which can be simplified to the level of farmers' knowledge and understanding. This will increase the water use efficiency. The information obtained during the study could only be used in making general comparisons between the different systems on water use efficiency but the real impact on overall efficiency can only be quantified with supporting data. In many irrigation schemes, the trend has been that more beneficiaries want access to water beyond the original design capacity of the scheme. Improving on water use efficiency would reduce occasional conflicts that arise when people compete for the available water.

14. Evaluation Limitations And Opportunities Of The Described Best Practices For Replication And Scaling Up

Lack of adequate information and supporting data on water use efficiency was limiting in evaluating different systems. The time allocated for field visits was inadequate to make good field situation analysis. Improvement of farmers' organization either in co-operative societies or water users associations and record keeping is vital for economic analysis of different systems. It was noted that the government provides backstopping services to the farmers' organizations. However the farmers need to be more pro-active in managing their systems. Poor accessibility to some areas makes it difficult to scale up the best practices.

15. Concluding Remarks and Observations

The study was well coordinated and guidelines were clear. The inception workshop was helpful in creating a forum for the consultants to share experiences within the Nile Basin. This also helped to harmonize the information across the region which is helpful in making comparative analysis of different systems.

The management and efficient utilization of the harvested water remains a challenge. The quality of harvested water for domestic use need more input in training and demonstrations.

The greatest challenge in Community Managed Irrigation (CMI) is lack of stable and organized market. The level of management is low in most of the schemes. The government support in management and infrastructural development has helped to sustain many of the community managed irrigation schemes. Gravity fed systems have been more sustainable than pumped systems. Some CMI schemes have strong co-operative societies that are actively involved in running and management of irrigation operations as it was found in Kibirigwi scheme.

Public Managed Irrigation had more investment in infrastructure, operation and maintenance and management system. There is active involvement of Water Users Association in running and management of the schemes. Gravity fed systems have been sustained for many years compared to pumped systems. The type of crops grown and market assurance play key roles in sustainability of the schemes.

16. Recommendations

In every agro-climatic zone, there are suitable water harvesting technologies that can be implemented to alleviate water shortage. The local conditions need to be evaluated prior to selecting the best practice for the area. Construction of water harvesting and storage structures can be easily done depending on the size, economic status of the community or individual and the intended use. Control of water loss through seepage, evaporation and siltation needs to be addressed. There is need for more input in maintaining good sanitation around the water facilities. Methods of water abstraction need to be improved to avoid contamination of the harvested water. During the field visits there was no clear information on the economics of different water harvesting systems. Economic analysis is necessary in prioritizing best water harvesting practices.

In community managed irrigation, the gravity fed system has less overhead cost in operation and maintenance. This was based on the information gathered during this study but it needs to be quantified with data which will need specific study. The participation of Water Users Association in running and management of the schemes need to be enhanced. The recent water reforms in Kenya requires establishment of Water Resources Users Associations which will be actively involved in water management for various uses

The management of public managed irrigation schemes was more complex because of the high number of beneficiaries involved and their expectations. The system in Perkera Irrigation Scheme where seed maize is grown under contract with a seed company has sustained the scheme for more than ten years. Such a system needs support of all stakeholders. Rice grown in Mwea Irrigation scheme has a wide market and traders come to buy rice from the farmers. A strong marketing organization would protect farmers from being exploited by traders or middlemen.

There is need to organize a longer study to allow for more information gathering on specific operations of water harvesting and irrigation systems. A critical path analysis needs to be done which would help in improving water use efficiency.

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Annex 1: Terms of Reference

Background

Agriculture, in general, plays a significant role in the livelihoods of households in the Nile Basin contributing greatly to economic growth and Gross Domestic Product (GDP). On the other hand, compared to the other sectors, agriculture is the main consumer of water. The riparian countries rely on the waters of the Nile River for their basic needs and economic growth, or have desires and expectations of harnessing the Nile for development activities. The agricultural sector is the dominant user of water in the basin but the luxurious and unchallenged use cannot be continued because of growing and competing demands from other sectors. There is a growing pressure to reduce the amount of water allocated for agricultural production mainly because of increasing demands from expanding urban centers, industry, mining, recreation and tourism. Agriculture is, therefore, expected to produce more crop per given volume of water if the system is to be sustained as a viable activity. Such a growing threat can best be addressed in a comprehensive way by collectively dealing on the subject at a basin level.

The Efficient Water Use for Agricultural Production (EWUAP) is one of eight projects of the Nile Basin Initiative's (NBI) Shared Vision Program (SVP). The EWUAP project is desired, therefore, to be a first step in bringing together the regional and national stakeholders in the riparian countries to develop a shared vision on common issues related to the increase of the availability of water and its efficient use for agricultural production.

The main thrust of the EWUAP Project is to establish a forum to assist stakeholders at regional, national, and community levels to address issues related to efficient use of water for agricultural production in the Nile Basin. The forum is expected to foster exchange of experiences furthering Nile cooperation by enhancing mutual confidence and providing a critical building block to the sustainable utilization of Nile waters. The EWUAP project will provide an opportunity to develop a sound conceptual and practical basis for Nile riparian countries to increase the availability and efficient use of water for agricultural production. The EWUAP is expected to meet its project objectives by bringing together regional and national stakeholders to have a common view and understanding on ways and means of improving water use in the sector and develop a shared vision on common issues. The project will create a framework to promote basin-wide cooperation and awareness, and build limited capacity by focusing on some of the common issues related to water harvesting and irrigation. The project will help establish forums to discuss broad development paths for the Nile Basin with a broad range of stakeholders; improve the understanding of the relationship between water resources development and agricultural activities; enhance basin wide cooperation and raise agricultural management capacities of basin wide institutions.

Expected key outputs for the project are as follows:

- Establishment of regional dialogue on Water Harvesting (WH);
- Strengthening of regional consultation on Community-Managed Irrigation (CMI) and enhancement of overall awareness on efficient water-use;
- Strengthening of regional consultation on Public and Private-Managed Irrigation (PMI) and the enhancement of awareness on efficient water-use;

- Exploring and disseminating best practices in water harvesting, community and private- public managed irrigation;
- Building national capacity for a sustainable management of water harvesting and irrigation practices; and
- Providing national level support for agriculture, water harvesting and irrigation policy development.

The improvement in water use efficiency has to be supported by knowledge and information sharing and this requires identification, documentation and dissemination of technologies and best practices from within and/or outside of the basin. Sharing of information could also be effected through study tours and field visits to sites of best practices with proven track record in terms of using technologies. In line with this, the EWUAP project would like to engage national consultants who will be involved in the identification, listing, description, and documentation of best practices and related best practice sites or centers. This is basically a desk review work supported by a targeted field visit, if deemed necessary. The consultancy will also include identification of key institutions/organizations in the agricultural water sectors, characterize the institutions, and describe their capacities to serve as national and/or regional partner for future joint activities.

Objectives of the Study

The main objective of the assignment is to identify and document best practices, sites of best practices, and list and provide a profile of potential institutions. The specific objectives of the study are to:

- Identify, list, and document best practices in the areas of Water Harvesting, Community-Managed Irrigation, and Public and Private-Managed Irrigation nationally;
- Select few preeminent practices from the list of best practices and technically provide a profile or detailed description of the preeminent practices;
- identify best practice sites for water harvesting, community managed irrigation, and public and private managed irrigation
- profile the selected best practice sites with indigenous and/or modern techniques since a selected number of these sites will be targeted for visits by national and/or regional practitioners for the exchange of experiences, and share of knowledge and information on the best practices on water harvesting, community managed irrigation and public private irrigation
- identify and list national institutions to be considered for twinning activities and then select and recommend few and provide a detailed profile description of these institutions with potential to organize and conduct capacity building activities and implement field level demonstrations or pilot activities in water harvesting and irrigation;

Study Location and Methodology

The required study and documentation activity will be carried out independently and concurrently in all nine riparian countries (Burundi, D. R. Congo, Egypt, Ethiopia, Kenya, Rwanda, Sudan, Tanzania, and Uganda). The national Consultant is expected to perform a desk review of documents, consult experts and resource persons, and if reckoned necessary make selected field visits and provide an overview and overall picture of the existing best practices, best practice sites, institutions with capacity for partnering in future activities related to water harvesting, community managed irrigation and public private irrigation with greater emphasis on efficient water use and productivity of water. Most of the required information in terms of best practices and associated sites as well as the potential institutions is believed to be documented and available with appropriate ministries, international agencies, institutions of higher learning, national, regional and international research organizations, NGOs, and many others.

Scope of Work

The requirements of EWUAP project are ambitious and cover the whole of the Nile Basin and member countries. It is divided into three main Components:

(i) Water Harvesting (WH)
(ii) Community-Managed Irrigation (CMI)
(iii) Public-Managed Irrigation (PMI)

Following on from the initial work on capacity building, training and awareness creation, in mid-2007 the project undertook Rapid Baseline Assessment (RBA) studies in almost all of the Member States using National Consultants. These reports provided an overview of the current status in each of the NBI countries and are now being finalized. EWUAP Project now wishes to expand and elaborate upon these RBA studies to establish for each Member State a list of sites suitable for illustrating best practices for all three main Components. This will be again undertaken through National Consultancies in each country to identify sites where interventions can be considered successful and that could possibly serve as examples of best practices associated with efficient water use in the sector for wider dissemination and training. For the greatest impact, it is important that the sites identified cover the full spectrum of technologies under different agro-ecological conditions available in each participating country.

To achieve this objective, and as part of the assignment, the Consultants will be required to complete fact sheets and details on each of the identified and recommended sites of best practice. These will be provided using standard formats, the outline of which will be provided to the Consultants on contract signature. In addition to this, further information will be needed and a minimum list of data requirements will also be provided on contract signature. These will include amongst other data, maps of Agro-Ecological Zones (AEZ) and definitions/properties used by each country, a list of all CMI and PMI schemes and an inventory of organizations involved in RWH including type of intervention and location.

EWUAP Project has developed draft criteria for defining best practices. In general this includes those projects or sites that are sustainable and could be used to show wider replicability of the technical, management, economic and social issues involved. When preparing the long and shortlist for possible projects that will meet these criteria, it is important that a matrix is prepared showing how the schemes have been selected and a ranking process developed to reach the priority list of best practice sites.

Based on the background information, project documents and details contained within the Rapid Baseline Assessment reports, the Consultant will undertake the following within the context of the above study objectives:

- Review the draft criteria of potential for best practices in the context of the country of study, using the three main project Components (water harvesting, community managed irrigation and public irrigation).
- In consultation with EWUAP/PMU agree and finalize criteria for best practice appropriate for the work to be undertaken in this study, and prepare a system for ranking and prioritizing of sites and schemes;
- Collect additional basic data from secondary sources to support the preliminary identification of the sites and to confirm the long list of best practice sites (EWUAP-PMU will provide formats and minimum requirements for this on signature of contract);
- Using the established and agree criteria, identify the range of technologies and criteria to be included in sites for best practices and establish a long list together with ranking values in order to determine a final shortlist for each country.
- Evaluate impact of the techniques on overall efficiency of water use in agriculture production, establishing how this is assessed and by providing support data and assessments;
- Prepare a final shortlist of potential sites by Component (WH, CMI, and PMI) that can be considered for illustrating the implementation of best practices as well as for training purposes both nationally and within NBI;
- For each of the short listed sites, prepare a detailed description according to an agreed format/checklist to be provided by the EWUAP-PMU on contract signature. This will include basic technical and physical details of the site, before and post project intervention situations including such key indicators as water use and productivity, management, operation and maintenance of the systems and the reasons why this site has been successful, why it has been chosen to illustrate best practices and the lessons learnt that can be applied to other areas;
- Analyze and identify any gaps within existing guidelines on WH, CMI, and PMI and prepare proposals for completing the guidelines considering the in-country experiences;
- Evaluate limitations and opportunities of the described techniques for replicability and scaling up;
- Participate in a 1-2 day discussion workshop to present the draft findings and details together with the Consultants from other member countries and representatives from NBI and the EWUAP;
- Following the workshop, finalize the details on best practice sites taking on board the results of the workshop discussions and the review of the initial reports and presentations made by EWUAP-PMU;
- From the initial short list of National Stakeholders provided in the RBA reports, and expanding on this list where necessary and appropriate, identify, list, and describe potential institutions to be used in organizing and conducting capacity building activities and field level demonstrations and dissemination of technologies/best practices in the fields of water harvesting and irrigation listing their experiences and previous involvement in such work and the roles that they could fulfill.
- Prepare a report that summarizes the results of the above that is supported by annexes that contain full details of all supporting data, calculations and justifications;
- Provide a complete list of references utilized in this study (and electronic copies where available) to include both publish project documents, working papers and project reports that may be unpublished but available within the country.

The consultant must keep in close contact with the PMU and establish a work plan for approval at the start of the assignment. On signature for the assignment, EWUAP Project

PMU will furnish the Consultant with draft formats and guidelines for the compilation of data as well as a report outline for presentation of the results of the study. It is envisaged that the BP sites will be first identified from available documentation and discussion with responsible government and non-government organizations. This will then be followed up by a limited number of sites visits to selected areas. Where possible, the field trip should combine potential Best Practice sites for more than one Component (WH, CMI and PMI).

DURATION OF ASSESSMENT WORK AND DELIVERABLES

The duration of services for the proposed country level assessment on best practices, guidelines, and identification of institutions has been estimated as four weeks time (up to 25 working days). If the Consultants consider that additional time will be required, then this should be set out in their proposals and programme.

The national Consultant will be selected from existing short list and/or a list supplied by Nile-TAC, Project Steering Committee (PSC) members, and National Project Coordinators (NPC). The NPCs will supervise the assessment work based on the final agreed estimates of time frame and programme based on the proposals prepared and submitted by the consultant.

Expected Outputs

A comprehensive assessment report(s) identifying, listing and describing best practices / technologies, best practice sites (centers of excellence), and appropriate institutions of the country. Each of the tasks set out under the scope of work above will be regarded as deliverables.

Monitoring and Supervision

This will be carried out by the PMU and the respective National Project Coordinators (NPC) in each of the Nile basin countries. Supervision and guidance will come from the NPC but in consultation with the Project Steering Committee (PSC) member and the Working Group members from the country. The services of the WH, CMI, and PMI Working Groups might also be used to provide invaluable assistance in guidance and technical inputs.

Methodology and Standards

The Consultant will be expected to employ the most effective methodology to achieve results. This study will basically involve a mixture of desk review work, consultation with relevant professionals, experts and resource persons, and when appropriate field visits;

In addition the Consultant is expected to:

- Participate and contribute during the inception workshop,
- Collect most of the data from existing primary and secondary sources,
- Use credible support staff in data and information collection,
- Prepare clear and concise reports,
- Make sure that the reports are delivered on the specified date(s),

- Communicate any unforeseen deviation from the agreed consultancy plan immediately, with clear justifications and proposed remedial course of action

Reference Documents

The following documents would be availed as reference background material:

i. Project Appraisal Document(PAD);
ii. Project Implementation Plan(PIP);
iii. Country based Rapid Baseline Assessment report;
iv. Technical note on criteria for best practices on water harvesting, community managed irrigation and public private irrigation

Time Frame

The proposed assessment work will commence on or about 20 October 2007 and be completed by the last week of December 2007 (Up to 25 working days).

Remuneration

The Consultant will be remunerated in accordance with the standard/official UNDP rates for National Consultants in each of the respective Nile basin countries. Reimbursable expenses will be made according to an agreed and approved plan.

Qualifications of the Consultant

- Advanced degree in water resources management, agriculture, irrigation , or related fields of study;
- Extensive experiences in water harvesting, irrigation (small and large scale), watershed management, crop and livestock production;
- At least ten years of experience in agricultural production, soil & water management, irrigation and natural resources management;
- Excellent knowledge of the agriculture practices, irrigation aspect, efficient use of water, and general environmental issues;
- Experience working in the country, particularly in the watersheds of the Nile River is an added advantage.
- Fluency in spoken and written English; knowledge of French an added advantage.
- Excellent presentation and communication skills.
- Excellent analytical skills.
- Good computer skills.
- Experience in having worked with/for an international or donor organization is an advantage.

Annex 2: Community Managed Irrigation - Rachuonyo And Homa Bay Districts

No	Project	Agro-Eco. zone	Yr of Dev	Main crops	Area (ha)			Agency		Farmer's Particip	Water source	Type of Irrig	Current status	Oper & Maint	Legal Status
					Potential	Deve	Actual crop	Donor	Implem.						
								Rachuonyo							
1	Seka Bondo	LM4	1982	Hort	18	17	2	SSIDP	PIU	Infield works	Lake Victoria	Pumpfed (furrow)	Stalled		Registered
2	Rongo Nyagowa	LM4	1979	Hort	25	20	15	KFFHC	PIU	Infield works	Lake Victoria	Pumpfed (furrow)	Stalled		Registered
3	Atandi	LM4	1984	Hort	130	5	5	IFAD	PIU	Infield works	Lake Victoria	Pumpfed (furrow)	Operational	Fair	Registered
4	Lanada	LM4	1994	Hort	80		25	IFAD	PIU	Infield works	Lake Victoria	Pumpfed (furrow)	Operational	Fair	Registered
5	Wagwe	LM4	1994	Hort	60	50	30	IFAD	PIU	Infield works	Lake Victoria	Pumpfed (furrow)	Operational	Fair	Registered
								Homa Bay							
1	Maugo	LM3	1986	Rice	340	300	200	EC	PIU	Infield works (part contri)	Mango River	Gravity Basin	Operational	Fair	Registere
2	Kandito	LM3	1984	Hort	250	5		Inst. For African Affairs (Italy)	LBDA	Infield works	Lake Victoria	Pumpfed grav.sprin.	Stalled		Registere
3	Wahambl a	LM4	1984	Hort	40	40	10	Farmers	DIU		Lake Victoria	Portable pump furrow	Operational	Good	Registere
4	Ngura	LM4	1984	Hort	25	20	15	IFAD	DIU	Infield works	Lake Victoria	Portable pump furrow	Operational	Good	Registere
5	Got Kokech	LM4	1982	Hort	25	10	25	Full Gospel Church	DIU	Infield works	Lake Victoria	Pumpfed furrow	Stalled		Registere
6	Nyagidha	LM4	1995	Hort	15	5	15	IFAD	DIU	Infield works	Lake Victoria	Treadle pump furrow	Operational	Fair	Registere

Annex 3: Community Managed Irrigation - Nyando District

No	Project	Agro-Eco. zone	Yr of Dev	Main crops	Area (ha)			Agency		Farmer's Particip	Water source	Type of Irrig	Current status	Oper & Maint	Legal Status
					Potential	Deve	Actual crop	Donor	Implem.						
								Nyando							
1	OYANDI NYACH ODA	LM4	1986	Hort	13	12	3	DUTCH GOV	PIU	Infield works (part contri)	Awach River	Gravity (furrow)	Not operational	Poor	Registered
2	KOPUDO	LM4	1990	Rice	44	40	40	DUTCH GOV	PIU	Infield works (part contri)	Awach River	Gravity (furrow)	Operational	Fair	Registered
3	WASARE	LM4	1986	Rice	240	164	120	DUTCH GOV	PIU	Infield works (part contri)	Awach River	Gravity (furrow)	Operational	Fair	Registered
4	GEM RAE	LM4	1986	Rice	150	90	90	DUTCH GOV	PIU	Infield works (part contri)	Awach River	Gravity (furrow)	Operational	Fair	Registered
5	NYABO NDO	LM4	1990	Rice	30	21	21	DUTCH GOV	PIU	Infield works (part contri)	Awach River	Gravity (furrow)	Operational	Fair	Registered
6	KOGOLA WOMEN GROUP	LM4	1992	Hort	70	65	2	DUTCH GOV	PIU	Infield works (part contri)	Asawo River	Gravity (furrow)	Operational	Fair	Registered
7	ALARA NYAHO DA	LM3	1990	Rice	40	40	36	DUTCH GOV	PIU	Infield works	Asawo River	Gravity Basin	Operational	Good	Registered
8	SIANY (CCI)	LM3	1992	Rice	37	33	33	DUTCH GOV	PIU	Infield works	Asawo River	Gravity Basin	Operational	fair	Registered
9	SOUTH WEST KANO	LM3	1990	Rice	1500	1000	800	EC/DUT CH GOV	PIU	Infield works	Nyando River	Gravity Basin	Operational	poor	Registered
10	KORE	LM3	1986	Rice	390	00	140	EC	PIU	Infield works (part contri)	Ombei River	Gravity Basin	Partly operational	Fair	Registered
11	ASUNDA	LM4	1988	Rice	30	25	25	DUTCH GOV	PIU	Infield works (part contri)	Ombei River	Gravity Basin	Operational	Good	Registered
12	ALUNGO A	LM4	1982	Rice	40	35	35	DUTCH GOV	PIU	Infield works (part contri)	Ombei River	Gravity Basin	Operational	Good	Registered
13	ABWAO	LM4	1990	Rice	35	32	32	DUTCH GOV	PIU	Infield works (part contri)	Ombei River	Gravity Basin	Operational	good	Registered
14	ODHON G	LM4	1992	Rice	100	90	30	DUTCH GOV	PIU	Infield works (part contri)	Ombei River	Gravity Basin	Operational	Fair	Registered
15	AWACH KANO DELTA	LM4	1982	Rice	200	170	150	DUTCH GOV	PIU	Infield works (part contri)	Awach River	Gravity Basin	Operational	Poor	Registered

Annex 4: Community Managed Irrigation - Suba And Bondo Districts

No	Project	Agro-Eco. zone	Yr of Dev	Main crops	Area (ha)			Agency		Farmer's Particip	Water source	Type of Irrig	Current status	Oper & Maint	Legal Status
					Potential	Deve	Actual crop	Donor	Implem.						
SUBA															
1	Kagwanga	LM5	1989	Hort	130	50	5	DANIDA	DIU	Infield system	Lake Victoria	Treadle pump (furrow)	Operational	Fair	Registered
2	Kolo	LM5	1990	Hort	300	10	5	?	DIU	Infield system	Lake Victoria	Bucket	Operational	Fair	Registered
3	Kirundo	LM5	1974	Hort	100	6	2	?	DIU	Infield system	Lake Victoria	Wind mill	Stalled		Registered
4	Anyango WG	LM5	1992	Hort	100	5	2	DANIDA	DIU	Infield system	Lake Victoria	Treadle pump (furrow)	Operational	Good	Registered
5	Nyakwar dani	LM5	1992	Hort	120	8	4	DANIDA	DIU	Infield system	Lake Victoria	Treadle pump (furrow)	Operational	Good	Registered
6	Nyaroya	LM5	1994	Hort	500	8	5	DANIDA	DIU	Infield system	Lake Victoria	Pumpfed furrow	Operational	Good	
7	Twableho WG	LM5	1998	Hort	250	8	4	Farmers initiative	DIU	Infield system	Lake Victoria	Pumpfed furrow	Operational	Fair	
8	Sindo jofwa	LM5	1994	Hort	100	5	2	Farmers initiative	DIU	Infield system	Lake Victoria	Pumpfed furrow	Operational	Fair	
BONDO															
1	Anyiko	LM3	1988	Rice	25	19	19	SSIDA	PIU	Infield works	River	Gravity (basin)	Operational	Fair	Registere
2	Nyangera	LM3	1987	Hort	6	1	1	SSIDA	PIU	Infield works	Lake Victoria	Hand pump (furrow)	Stalled		Registere
3	Ugambe	LM4	1989	Hort	70	24	20	KFFHC	PIU	Infield works	Lake Victoria	Pumpfed furrow	Partly operational	Poor	Registere
4	Nyandusi	LM4	1981	Hort	5	5	5	SSIDA	PIU	Infield works	Lake Victoria	Pumpfed furrow	Operational	Fair	Registere
5	Wagusu	LM4	1985	Hort	35	4	4	SSIDA	PIU	Infield works	Lake Victoria	Pumpfed furrow	Operational	Fair	Registere
6	Likhungu	LM4	1985	Hort	7	4	4	SSIDA	PIU	Infield works	Lake Victoria	Pumpfed furrow	Operational	Good	Registere
7	Nyandiwa	LM4	1989		Hort	6	4	IFAD	PIU	Infield works	Nyando River	Gravity (furrow)	Operational	Fair	Registere
8	Usia masaba	LM4	1992	Hort	20	20	20	SSIDA	PIU	Infield works	Yala River	Gravity (furrow)	Operational	Fair	Registere

9	Anduro	LM4	1990	Hort	10	6	5	IFAD	PIU	Infield works	Sirombe River	Gravity (furrow)	Operational	Poor	Registere
10	Kokise	LM4	1982	Hort	20	10	5	SSIDA	PIU	Infield works	Lake Victoria	Pumpfed furrow	Stalled		Registere
11	Kinda	LM4	1986	Hort	30	5	2	IFAD	PIU	Infield works	Lake Victoria	Pumpfed furrow	Operational	Fair	Registere

Annex 5: Community Managed Irrigation - Central Province

No	Project	Agro-Eco. zone	Yr of Dev	Main crops	Area (ha)			Agency		Farmer's Particip	Water source	Type of Irrig	Current status	Oper & Maint	Legal Status
					Potential	Deve	Actual crop	Donor	Implem.						
1	KibirigwI	LH3	1980	Hort	200	120	111	GOV	PIU	Infield works	Ragati River	Sprinkler	Operational	Good	Registered
2	Mitunguu	LH3	1980	Hort	200	100	80	GOK	PIU	Infield works	Mitunguu River	Sprinkler	Operational	Good	Registered

ANNEX 6: NEW COMMUNITY MANAGED IRRIGATION SCHEMES - RIFT VALLEY PROVINCE

No	Project	Agro-Eco. zone	Yr of Dev	Main crops	Area (ha)			Agency		Farmer's Particip	Water source	Type of Irrig	Current status	Oper & Maint	Legal Status
					Potential	Deve	Actual crop	Donor	Implem.						
1	Weiwei	LM4	1986	Seed maize	800	600	500	GOK & Italian gov.	PIU	Infield works	Weiwei River	Sprinkler	Operational	Good	Registered
2	Arror	LM4	1990	Vege. & cereals	600	400	300	GOK	PIU	Infield works	Arror River	Gravity (furrow)	Operational	Good	Registered

Annex 7: Public Managed Irrigation Schemes - Nyanza Province

No	Project	Agro-Eco. zone	Yr of Dev	Main crops	Area (ha)			Agency		Farmer Particip	Water source	Type of Irrigation	Current status	Oper & Maint	Legal Status
					Potent	Dev	Actual crop	Donor	Implementer						
1	Ahero pilot irrigation scheme	LM4	1969	Rice, Sugarcane	870	870	120	DUTCH GOV.	NIB	NIL	River Nyando	Punpfed Basin	Operational	Poor	NIB
2	West Kano irrigation project	LM4	1976	Rice, Sugarcane	880	880		DUTCH GOV.	NIB	NIL	Lake Victoria	Punpfed Basin	Operational	Poor	NIB
3	Bunyala	LM4	1996/7						NIB	NIL					
4	Kenya sugar research foundation irrigation project (Kibos)	LM4	1996/7	Sugarcane	112	112	56	GOK	KSA/KARI	NIL	River Kibos	Pumpfed, Drip & Splinkler (Supplemental)	Operational	Good	Private (Institution)
5	Kari striger research irrigation project	LM4	2002	Maize, Simsim, Rice, IRainfed)	5	5	5	Rocker Fellor Foundation	KARI	NIL	River Kibos	Pumpfed, Drip & Splinkler (Supplementa	Operational	Good	Private (Institution)
6	Kenya sugar research foundation irrigation project (opapo)	LM4	1996	Sugarcane				GOK	KSA/KARI	NIL	Borehole and Sub-surface drainage	Pump fed Drip (manual) Supplemental	Operational	Good	Private (Institution)
7	Chemelil sugar factory irrigation project	LM4	1997	Sugarcane	1500	400	400	CSC	CSC	NIL	Tributary of River Nyando	Pumpfed, Splinkler & Furrow (Supplemental)	Operational	Fair	Private (Institution)
8	ICIPE-Mbita field station irrigation project	LM5	1988	Cereals (Integrated Pest Control Res.)	10	10	5	ICIPE	ICIPE	NIL	Lake Victoria	Pumpfed, Splinkler (Supplemental)	Operational	Good	Private (Institution)
9	ICIPE – banana research irrigation project (Ungoye)	LM5	1992	Bananas (Research and Bulking)	25	10	5	ICIPE	ICIPE	NIL	Lake Victoria	Pumpfed, Splinkler (Supplemental	Operational	Good	Private (Institution)

Annex 8: Public Managed Irrigation Schemes - Rift Valley, Central And Coast Provinces

No	Project	Agro-Eco. zone	Yr of Dev	Main crops	Area (ha)			Agency		Farmer Particip	Water source	Type of Irrigation	Current status	Oper & Maint	Legal Status
					Potent	Dev	Actual crop	Donor	Imple menter						
RIFT VALLEY PROVINCE															
1	Perkera	LM4	1954	Hort, seed maize	2340	810	607	GOK	NIB	Field operation	Perkera River	Gravity Furrow	Operational	Good	NIB
CENTRAL PROVINCE															
2	Mwea	LM3	1956	Rice, Hort	30,350	16,000	16,000	GOK	NIB	Field operation	Nyamindi & Thiba Rivers	Gravity flood basins	Operational	Good	NIB
COAST PROVINCE															
3	Bura	LM5	1978	Maize, Simsim, Rice, IRainfed)	6,700	2,500	1,000	WB, ODA, EEC UNDP	NIB	Field operation sL	Tana River	Pumpfed/gravit y	Operational	Good	NIB
4	Tana (Hola)	LM5	1953	Cotton	4,800	900		GOK	NIBI	NIL	Tana River	Pumpfed/gravit y	Stalled	Stalled	NIB

Annex 9: New Public Managed Irrigation Schemes - Nyanza Province

No	Project	Agro-Eco. zone	Yr of Dev	Main crops	Area (ha)			Agency		Farmer's Particip	Water source	Type of Irrig	Current status	Oper & Maint	Legal Status
					Potential	Deve	Actual crop	Donor	Implem .						
1	Kimira-Oluch	LM3/ LM4	2003	Rice, Cotton , Vege. Cereal	3,676	1,500	500	GOK	PIU	Infield works	Lake Victoria	Pumped/grav ity	To start	To start	Registered
2	Dominion Farms	LM4	2003	Rice, Maize, Cotton	17,000	5,600	3,000	DLF	DLF	Labour	Yala River	Gravity	Operational	Good	Private (company)

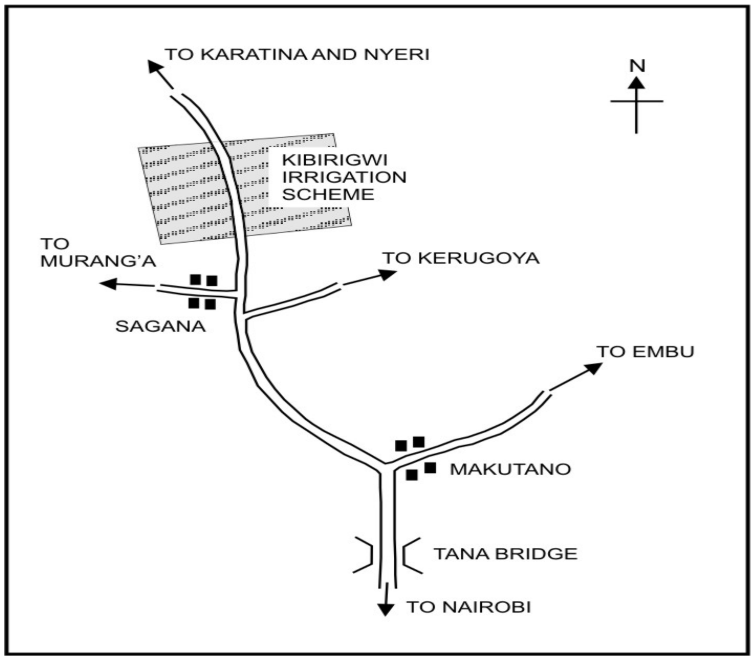
Annex 10: List Of People Consulted Directly

	Name	Organization	Contact
1	Mr. Ben Massawe	National Irrigation Board, Perkera Irrigation Scheme	0721 561929
2	Mr. Simon Kamundia	National Irrigation Board, Mwea Irrigation Scheme	0722 621806 skamundia@yahoo.com
3	Mr. Philip Langat	Ministry of Agriculture, Land Development Divison-Nairobi	0727 214023
4	Mr. James Mugo	National Irrigation Board, Mwea Irrigation Scheme	P.O Box 80 Wanguru - 10303
5	Professor Chemelil	Egerton University, Njoro	P.O Box 536 Njoro
6	Mr. Isaya V. Sijali	KARI, National Agricultural Research Laboratories - Nairobi	0722 764751
7	Mr. Gerald G. Muigai	Kibirigwi Irrigation Sheme	0721 683478
8	Eng. Hosea Wendot	National Irrigation Board, Nairobi	0722 977617 wendot12@yahoo.com
9	Dr. Tadele Gebreselassie	EWUAP , Nairobi	tgebreselassie@nilebasin.org
10	Mr. Vincent Kabalisa	EWUAP, Nairobi	vkabalisa@nile basin.org
11	Mr. Geofrey O. Wekesa	Lake Basin Development Authority (LBDA), Kisumu	0722 867719 lakebasinauth@yahoo.com
12	Mr. Alex Oduor	ICRAF, Nairobi	0728 025379
13	Mr. Joseph Sang	ICRAF, Nairobi	0722 574798

Annex 11 :Best Practice Site (Cmi) Kibirigwi Irrigation Scheme, Kirinyaga District, Central Province

Date of Visit: 04/12/07	Category: CMI small scale sprinkler irrigation
Name of Site: Kibirigwi irrigation scheme	Community managed irrigation

Sketch Map of Site



Geographic location of practice: 70 kilometres North of Thika town along Karatina-Sagana road in Kiina location, Ndia Division, Kirinyaga district in Central province. 1,026 metres a.s.l

(GPS) Coordinates: S 00º 33' 46.3" E 037º 11' 17.4"

Description of the Community: (Including no of beneficiaries; gender groups; number of households; names of villages; overall population; etc).
Beneficiaries include 277 households according to original plan.

Characteristics of the area: Lowland and relatively flat topography.

Climate (AEZ) + Description: (Sets the climatic context - Arid; semi-arid; humid tropics; Mediterranean - Influences the types of crops that can be grown). Humid area - AEZ LH3

Average annual rainfall (mm); 1,900

Months of Short Rains:	October -December

Months of Main Rains:	March – May
Mean annual ref. crop Evapotranspiration (mm):	
Predominant soil type:	Clay loam
Topography:	Gently sloping
Slope:	
Erosion:	Not a major problem in irrigated fields
Period of year during which used:	All year round
Period of year during which benefits utilized:	All year round

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).

Water source is from Ragati River, a tributary of Sagana river.

Irrigated area: (Total annual and then by season (ha): 110 ha

Method of water abstraction: (Pumped; gravity; artesian - Influences the pattern of supply and cost of irrigation water): Sprinkler irrigation system.

Water delivery infrastructure: (Open channel; pipelines; lined; unlined - Influences the potential level of performance.): Main pipeline

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 - Influences the potential level of performance): Sprinkler irrigation.

Major crops (with percentages of total irrigated area): (Sets the agricultural context. Separates out rice and non-rice schemes, monoculture from mixed cropping schemes): French beans.

Average farm size: (Important for comparison between schemes, whether they are large estates or smallholder schemes). 0.4 ha

Type of management: (Government agency; private company; joint government agency/farmer; farmer-managed - Influences the potential level of performance):
Joint management between government and farmers through Kibirigwi Farmers' Co-operative Society.

Technical Description: (Please describe in about 250 words the background of the irrigation development, how it is used, how it achieves its objectives and its main purpose - For local markets; home consumption; regional or national markets; export):

<table>
<tr><td colspan="2">Kibirigwi irrigation scheme was started jointly by Ministry of Agriculture (MOA) and Tana and Athi Rivers development Authority (TARDA) in 1975 and implemented between 1977 and 1980. The first crop was irrigated in 1980. The project was co-funded by Kenya government and Netherlands Technical co-operation aide at a cost of Ksh. 12 million. The objective was to establish commercial vegetable production under irrigation with an ultimate target of 240 ha cultivated annually. Establishment of a proper managed co-operative society. Establish a system of water distribution, and methods of operation and maintenance of the irrigation system. Implement soil conservation programme within the wider catchment. Develop a method of cost recovery and maintain a sustainable farm income. Strengthen the cooperative society to take over the running of the irrigation scheme.</td></tr>
<tr><td colspan="2">Technical Details: (Describe the studies that were carried out before implementation, any design manuals or guidelines that were used for implementation, Relevant Reports and Design Data used in Designs, and any major calculations made including runoff, available water supplies irrigation area or number of people supplied with water etc.):

Feasibility studies were done by Kenya and Netherlands governments which showed that the potential of using gravity sprinkler irrigation system in Kibirigwi. Initially the area was under grazing. There used to be a cultural belief that the area was not suitable for farming and was reserved only for grazing. The system was initially designed for 277 households but now serving 377 farm users and 147 domestic users. The system consists of: Headwork-weir and intake box, Settling tanks, 8.65 km main line of 12", 10", 8" and 6" diameter towards the end. There are 25 lateral take off lines, 243 hydrants, and Field hydrants, 104,150 pressure regulators to ensure proper working pressure of 2.5 atmospheres at the sprinklers. Each farmer was given 2 sprinklers detachable for shifting to other sprinkler position with capacity to irrigate 0.4 ha.</td></tr>
<tr><td>Useful in: Describe the types of area where it can be used, the conditions where it produces good results, Sites of applications, etc.

Area with similar topography where water can be abstracted from the river at a higher elevation to irrigate in the lowland.</td><td>Limitations: Describe the conditions or situations where it does not perform well and conditions that will restrict its wider application:

There has to be sufficient elevation difference between the intake and the irrigated fields to create adequate pressure to rotate the sprinklers. The number of users at a given time has to be regulated to maintain the right sprinkler operating pressure.</td></tr>
<tr><td>Geographical extent of use: The areas of the study country where it is found and the sort of areas where it could be used within the Nile Basin.

Any other area with similar site characteristics like Kibirigwi. A group of farmers have organized themselves and initiating another scheme about 10 km south east of Kibirigwi along the Sagan river.</td><td>Effectiveness: (Describe whether it has achieved its objectives, how well it has done and the general strengths of the practice and whether it has in fact achieved what it set out to do):

The objectives of the scheme has been met by producing an average of 10 tons of French beans per ha. In the year 2005 the total production of French beans was 300,000 kgs worth Ksh. 9 million.</td></tr>
<tr><td colspan="2">Other Sites where used: There are two other similar small irrigation schemes one at the foot slopes of Mount Kenya and another one called Mitunguu irrigation scheme in Meru Central District.</td></tr>
</table>

Cost: (If possible, and applicable, please indicate the total budget for the best practice, the sources of funding, the implementation period, the total cost and cost per cubic metre of water stored or per ha irrigated, beneficiary contributions, etc.): The beneficiaries pay operation and maintenance fee to the co-operative society for water supply of Kenya shillings 1,200 per year. The farmers have to meet all the other production cost of ploughing, seed, fertilizer, labour for all operations and maintenance of the system in their farms.	**Operation and Maintenance arrangements:** (Who manages, operates and maintains the works, how this is funded, contributions levied per user, percentage of payment received against amounts requested, any assistance and support received from Government or other organizations, etc): The co-operative society and the farmers are involved in operation and maintenance. The main activities are repairing and servicing all the components along the main line and lateral take-off lines. However due to the age of the project there has been faults in pressure regulators mainly along the lateral take offs, leading to unbalance pressure and hence low water use efficiency. Pipe bursts are frequent during rainy season that need repair. At this period water demand is usually low and thus creating high pressure along the line. Other components requiring repair works are sluice valves, broken sprinklers and worn out threads.
Benefits: (Estimate the returns achieved from the site if involves irrigation or costs saved in getting water for humans or livestock): The water is also used for domestic and livestock in addition to irrigation. During the rains the water demand is low.	**Water User Association or User Group:** (Provide details of the type of organization, how it works and elects members, number of members and all other pertinent details): Water Users Association (WUA) was formed but has not been operational. The problem was that the same officials of the co-operative society were more than 70 % the same officials of the WUA. The association is at the moment dormant but with the current water sector reforms in Kenya it is hoped that the association will be revived and start operating according to the legal requirements in the water act.
Stakeholders and beneficiaries: (Who are the main initiators, actors, stakeholders, beneficiaries and users? How and why are they involved in the practice? Actual level of beneficiary involvement under operation): The government initiated the project with the assistance of the Netherlands government. Ministries of agriculture and co-operative development act on behalf of the government. The community through the co-operative society and the company that contracts the farmers to grow French beans are also key stakeholders.	**Enabling Environment:** (Policies, design standards and manuals that made the concept possible, where the community obtained the idea, was it demand based or introduced by Government or private sector initiatives, etc.): The scheme was initially developed by Kenya government and is within the policy of irrigation development in Kenya.

Training support: (Details of any training carried out before, during and after construction and how the community has benefited from this): There has been continuous capacity building to farmers and their leaders by the ministry of agriculture, ministry of co-operative development and other NGOs.	**Extension support:** (Details of any extension services provided and whether any help is given in assessing annual O&M needs and preparing costs and how the community has benefited from this): The government through the ministry of agriculture has been assisting in training the community leaders in operation and maintenance as well as agronomic practices.
Environment benefits: (Whether it has been completed as part of part of watershed development or intergated management approach, how it fits in, visible benefits achived in terms or water avaialability, reduction in erosion, vegetative growth etc): The initial project design had a component of soil conservation within the wider catchment of the area. Terracing has been done and also agroforestry that has modified the landscape. There is still more that need to be done.	**Social/Cultural acceptability:** The original cultural belief that the area was not suitable for farming has changed over the years. People have accepted that the Kibirigwi irrigation scheme is a nucleus of economic development of the area.
Advantages: (Strengths of the approach adopted, how well it fits into the community and meets its needs, is it affordable and replicable, will the community continue to operate, maintain and use it after outside assistance has gone and reasons for this etc.). The cost of maintaining the system is not high but the management level of the co-operative society is low. The system of cost recovery from the farmers is inefficient and as such the maintenance of the basic infrastructure is poor. There are many farmers who default in payment for water supply services and that is loss of revenue to the society. The contract farming for French bean production by a processing company in Nairobi creates market for the produce.	**Disadvantages:** (Constraints that restricts its effectiveness, the risks involved in its developments, the conditions under which it will not work or have reduced impact etc.). Non payment of operation and maintenance fee by some farmers. The management level of the farmers' co-operative society is low. The WUA has not been strengthened.
Scaling Up: (Are there specific conditions or obstacles which make it impossible to replicate or transfer the practice elsewhere - e.g., a specific climate or specific cultural beliefs or social relations which are important for the success of this practice ;): The success of Kibirigwi irrigation scheme has led to establishment of two other small scale community managed irrigation schemes**.**	What is potential for applying all/parts of initiative elsewhere? **(Score from 1 to 10 on list below with 10 being highly applicable)** I [9] Transfer of practice to another group/culture/land-use system, etc. II [8] Easy to transfer the practice, but with minor adaptations for local conditions III [7] Transfer possible, but significant

	modifications/prerequisites to consider. IV [3] Difficult to transfer the practice. Need experienced support. V [4] It would be impossible to transfer the practice. Too site specific. **Other specific remarks:** (e.g., agreements, regulations, provisions regarding Intellectual Property Rights, etc.) Provision to be within a legal framework.

Best Practices: (Why this site/ case is considered to be a successful best practice; express this success in qualitative or quantitative terms; whether all or only part of the practices of the site can be considered best Practice - name them and give reasons why and provide any Conclusion and Recommendations).

Good potential for horticultural production. Involvement of farmers' co-operative society 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. High economic returns on investment.

Contact Organization: (For further information; site visits' etc)	
Type of organization: [*] government organization [ ] private organization [ ] NGO &/or CBO [ ] international agency [ ] other:	Contact person: Mr. Wachira Contact details: Scheme manager, Kibirigwi irrigation scheme.

Lessons learnt: (at various stages of the realization of the works, describe any lessons learnt that would improve upon future similar interventions)

Planning: Involvement of all stakeholders in the project area through consultations, co-ordination and communication.

Design: The scheme operation is below the design capacity due to inadequate water and poor maintenance strategy.

Construction: Use of locally available materials and trained personnel in the fields of engineering, quantity survey

Implementation: Use of technically qualified people in construction and maintenance of the irrigation facilities and agronomic practices.

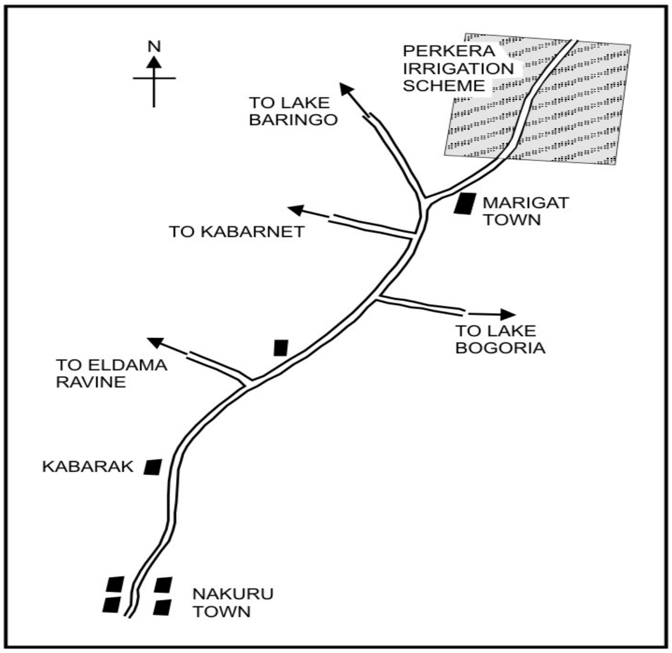
O&M: Training of WUAS on operation, control and maintenance of irrigation facilities and production processes. Routine repair of pipelines and sprinklers. Strengthening WUA and co-operative society and having regular meetings with all stakeholders.

Beneficiary involvement: Beneficiaries should be actively involved in decision making and day to day running of the project through their elected leaders. This will raise their sense of ownership of the scheme for sustainability.
Realization of benefits: Such as markets; achieving better returns - crop selection &/or market linkages etc).Production of seed maize has been very profitable. There is a lot of money exchange amongst the people in Kibirigwi as a result of good market price for the French beans and other produce. New buildings and diverse businesses have been established in Kibirigwi town for the last 10 years. There has been major transformation of the lives of people in Kibirigwi because of the scheme.
Other Remarks or observations: Despite the management problems that have existed for long, Kibirigwi irrigation scheme has become sustainable because of market assurance and prompt payment to the farmers. This has come about due to sustained French beans production through growing contract agreement with a processing company, better and prompt payment to farmers and increased participation of farmers in day to day running of the scheme through the co-operative society. There is more room to investigate ways of increasing water use efficiency.
Contact person completing form: Gerald Gichia Muigai
Contact details: Kibirigwi Irrigation Scheme, P.O. Box 474, Karatina Mobile phone 0721683478

Annex 12; Best Practice Site (Pmi) Perkera Irrigation Scheme, Baringo District, Rift Valley Province

Date of Visit 05/12/07	**Category: Public Irrigation Scheme**
Name of Site: Perkera irrigation scheme	Public Irrigation Scheme

Sketch Map of Perkera irrigation scheme site



Geographic location of practice: 100 kilometres North of Nakuru town near Marigat Township in Baringo district. 1,036 metres a.s.l

(GPS) Coordinates: S 00º 28' 11.1" E 035º 58' 51.3"

Description of the Community: (Including no of beneficiaries; gender groups; number of households; names of villages; overall population; etc):
Beneficiaries include 672 households

Characteristics of the area: Lowland and relatively flat topography.

Climate (AEZ) + Description: (Sets the climatic context - Arid; semi-arid; humid tropics; Mediterranean - Influences the types of crops that can be grown):
Semi-arid area AEZ LM5

Average annual rainfall (mm); 600	
Months of Short Rains:	October -December
Months of Main Rains:	March – May
Mean annual ref. crop Evapotranspiration (mm):	
Predominant soil type:	Silt clay
Topography:	very gently sloping

Slope:	Less than 5 %)
Erosion:	Riverbank erosion is a major problem
Period of year during which used:	All year round
Period of year during which benefits utilised:	All year round

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).

Water for irrigation is from Perkera river which is perennial but the flow fluctuates with very critical low flows between August and March.

Irrigated area: (Total annual and then by season (ha)): 810 ha out of which 500 ha are cropped per season.

Method of water abstraction: (Pumped; gravity; artesian - Influences the pattern of supply and cost of irrigation water): Gravity irrigation system.

Water delivery infrastructure: (Open channel; pipelines; lined; unlined - Influences the potential level of performance.): Open channel mostly unlined 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 - Influences the potential level of performance): Furrow irrigation

Major crops (with percentages of total irrigated area): (Sets the agricultural context. Separates out rice and non-rice schemes, monoculture from mixed cropping schemes): Certified seed maize

Average farm size: (Important for comparison between schemes, whether they are large estates or smallholder schemes). 1.6 ha

Type of management: (Government agency; private company; joint government agency/farmer; farmer-managed - Influences the potential level of performance):

Joint management between government and farmers through Water Users Association.

Technical Description: (Please describe in about 250 words the background of the irrigation development, how it is used, how it achieves its objectives and its main purpose - For local markets; home consumption; regional or national markets; export):

Perkera irrigation scheme was started in 1954 by political detainees who provided labour for construction. The first crop of onions was planted in 1956 on 567 ha. The potential area for irrigation is 2,348 ha. In early 1960s 120 ha was added to the already cultivated area but was abandoned after one season when it was realized that irrigation water was not enough to cater for all the area developed. At present the total area developed for furrow irrigation is 810 ha out of which only 500 ha is cropped per season. Initially the scheme was a major source of bulbed onions, dried chillies and watermelon. Other crops included pawpaw and cotton. Farmers abandoned production of the above crops due to marketing problems. In 1996 farmers started growing seed maize under contract agreement with Kenya Seed Company. To date this is the major crop in the scheme since 1996.

Technical Details: (Describe the studies that were carried out before implementation, any design manuals or guidelines that were used for implementation, Relevant Reports and Design Data used in Designs, and any major calculations made including runoff, available water supplies irrigation area or number of people supplied with water etc.):

<table>
<tr><td colspan="2">Feasibility studies which showed that the jemps flats were suitable for irrigation. the last study was done in 1936 but due to financial constraints construction was not started until 1954 when political detainees provided labour for construction. Hydrological survey involving river discharge and water quality of Perkera river.</td></tr>
<tr><td>Useful in: Describe the types of area where it can be used, the conditions where it produces good results, Sites of applications, etc):

Area with gently undulating topography. Land which has low slopes. Areas with silt clay loam soils and availability of water for irrigation.</td><td>Limitations: Describe the conditions or situations where it does not perform well and conditions that will restrict its wider application:

Where land is in a steep area and highly permeable soils. Inadequate water for irrigation.</td></tr>
<tr><td>Geographical extent of use: The areas of the study country where it is found and the sort of areas where it could be used within the Nile Basin):

Any other area with similar site characteristics like Perkera in Marigat division of Baringo district. At Weiwei irrigation scheme in West Pokot district, there has been introduction of sprinkler irrigation to improve on water use efficiency.</td><td>Effectiveness: (Describe whether it has achieved its objectives, how well it has done and the general strengths of the practice and whether it has in fact achieved what it set out to do):

The objectives of the scheme has been met by producing an average of 2.5 million kilogrammes of seed maize with a gross value of Ksh. 80.0 million of which a total net of Ksh. 60.0 million paid to the farmers.</td></tr>
<tr><td colspan="2">Other Sites where used: Weiwei irrigation scheme in West Pokot district in Rift Valley Province.</td></tr>
<tr><td>Cost: (If possible, and applicable, please indicate the total budget for the best practice, the sources of funding, the implementation period, the total cost and cost per cubic metre of water stored or per ha irrigated, beneficiary contributions, etc):

The beneficiaries pay operation and maintenance cost to NIB for irrigation water supply of Kenya shillings 2,000 per year. The farmers have to meet all the other production cost of ploughing, seed, fertilizer and labour for all operations.</td><td>Operation and Maintenance arrangements: (Who manages, operates and maintains the works, how this is funded, contributions levied per user, percentage of payment received against amounts requested, any assistance and support received from Government or other organisations, etc):

NIB manages and maintains water distribution system at the intake and major canals. The farmers manage and maintain the branch canals and the line canals to the farms. NIB signs the contract agreement with Kenya seed company on behalf of the farmers. The payments for seed delivery is made payable to NIB. Water Users Association committee on behalf of the farmers' co-operative society works with NIB in sorting out the payments to the farmers and to make sure that all production cost credited to the farmers are recovered from their sale of seed maize.</td></tr>
</table>

Benefits: (Estimate the returns achieved from the site if involves irrigation or costs saved in getting water if water for humans or livestock): The water is also used for domestic and livestock. During the off-season of seed maize production, the water is also used in horticultural farming.	**Water User Association or User Group:** (Provide details of the type of organization, how it works and elects members, number of members and all other pertinent details): Water Users Association (WUA) is very active in irrigation water management. The elected leaders of the association are members of the planning committee that oversees the activities of the scheme on behalf of the farmers.
Stakeholders and beneficiaries: (Who are the main initiators, actors, stakeholders, beneficiaries and users? How and why are they involved in the practice? Actual level of beneficiary involvement under operation): The government initiated the project and was later put under the management of National Irrigation Board (NIB). There has been assistance by other organizations such as Kenya Seed Company in marketing and Teachers Saving and Credit co-operative Society (SACCO) in credit provision for input supply.	**Enabling Environment:** (Policies, design standards and manuals that made the concept possible, where the community obtained the idea, was it demand based or introduced by Government or private sector initiatives, etc.): The scheme was introduced by the government and is within the policy of irrigation development in Kenya.
Training support: (Details of any training carried out before, during and after construction and how the community has benefited from this): There has been continuous capacity building to farmers and their leaders by NIB and other stakeholders.	**Extension support:** (Details of any extension services provided and whether any help is given in assessing annual O&M needs and preparing costs and how the community has benefited from this): The government through NIB has been assisting in training community leaders in operation and maintenance.
Environment benefits: (Whether it has been completed as part of part of watershed development or integrated management approach, how it fits in, visible benefits achieved in terms or water availability, reduction in erosion, vegetative growth etc): Furrow irrigation helps in ground water recharge which helps in improving the environment. Vegetation remains healthy and green throughout the year when in other areas outside the scheme the vegetation is water stressed and has low biomass production.	**Social/Cultural acceptability:** There are two major groups of people in Marigat, i.e. pastoralists and agro-pastoralists. The pastoralists occasionally graze their livestock in the irrigated fields and in the process destroy the crops and damage canals. This is a major conflict that makes irrigation farming difficult. However the conflicts are resolved by the community leaders. Apart from this the scheme has been accepted by all the local community as a major economic base in the area.

Advantages: (Strengths of the approach adopted, how well it fits into the community and meets its needs, is it affordable and replicable, will the community continue to operate, maintain and use it after outside assistance has gone and reasons for this etc.): With 100 % payment of operation and maintenance fee by all land users through Water Users Association the scheme operations can be sustained. In contract farming there is assurance of market for the produce and if this is maintained the scheme will be sustainable for many years to come assuming that there will be adequate water.	**Disadvantages:** (Constraints that restrict its effectiveness, the risks involved in its developments, the conditions under which it will not work or have reduced impact etc.): Non payment of operation and maintenance fee by some farmers. The management level of the farmers' co-operative society is low and Kenya Seed Company has no confidence with the society's management. That is why the seed company signs contract agreement with NIB. This means that If NIB hands over the scheme management to the farmers' society, there can be problem in marketing and hence sustainability of the scheme.
Scaling Up: (Are there specific conditions or obstacles which make it impossible to replicate or transfer the practice elsewhere - e.g., a specific climate or specific cultural beliefs or social relations which are important for the success of this practice): The success of Perkera irrigation scheme has led to establishment of two other small scale community managed irrigation schemes namely Eldume along Waseges river that drains from Ndondori catchment through Subukia to Lake Bogoria and Sandai irrigation scheme along Molo river that is a tributary of Perkera river. Each of the two schemes covers an area of 120 ha each.	What is potential for applying all/parts of initiative elsewhere? (Score from 1 to 10 on list below with 10 being highly applicable) I [8] Transfer of practice to another group/culture/land-use system, etc. II [9] Easy to transfer the practice, but with minor adaptations for local conditions III [7] Transfer possible, but significant modifications/prerequisites to consider. IV [3] Difficult to transfer the practice. Need experienced support. V [2] It would be impossible to transfer the practice. Too site specific. Other specific remarks: (e.g., agreements, regulations, provisions regarding Intellectual Property Rights, etc.) Provision to be within a legal framework.
Best Practices: (Why this site/ case is considered to be a successful best practice; express this success in qualitative or quantitative terms; whether all or only part of the practices of the site can be considered best Practice - name them and give reasons why and provide any Conclusion and Recommendations): 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.	
Contact Organization: (For further information; site visits' etc)	
Type of organization: [*] government organization [ ] private	Contact person: Mr. Ben Massawe Contact details: Scheme manager, Perkera irrigation scheme.

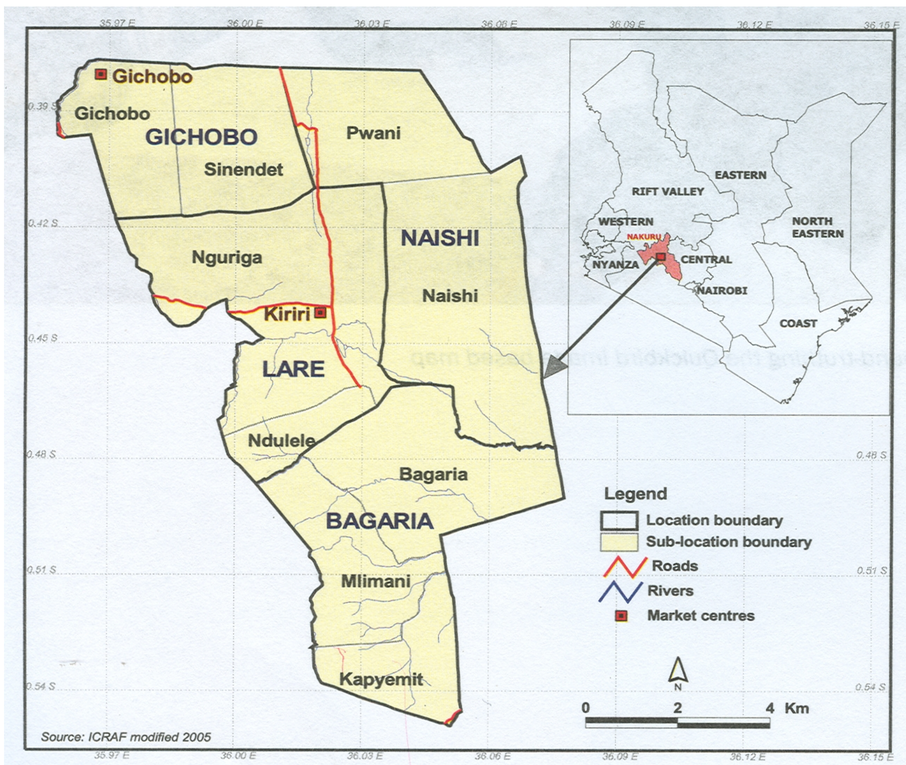
organization [ ] NGO &/or CBO [ ] international agency [ ] other:	

Lessons learnt: (at various stages of the realization of the works, describe any lessons learnt that would improve upon future similar interventions)
Planning: Involvement of all stakeholders in the project area through consultations, co-ordination and communication.
Design: The scheme operation is below the design capacity due to inadequate water.
Construction: Use of locally available materials and trained personnel in the fields of engineering, quantity survey
Implementation: Use of technically qualified people in construction and maintenance of the irrigation facilities.
O&M: Training of WUAS on operation, control and maintenance of irrigation facilities and production processes. Routine cleaning and repair of canals and intake. Regular meetings with WUAS leaders and NIB staff.
Beneficiary involvement: Beneficiaries should be actively involved in decision making and day to day running of the project through their elected leaders. This will raise their sense of ownership of the scheme for sustainability.
Realizations of benefits: Such as markets; achieving better returns - crop selection &/or market linkages etc).Production of seed maize has been very profitable. There is a lot of money exchange amongst the people in Marigat as a result of good market price for the seed maize. New buildings and diverse businesses have been established in Marigat town for the last 10 years that seed maize has been grown in Perkera irrigation scheme. There has been major transformation of the lives of people in Marigat because of the scheme.
Other Remarks or observations: Despite the small size of operation due to inadequate water, Perkera irrigation scheme has become sustainable because of market assurance and prompt payment to the farmers. This has come about due to sustained seed production through growing contract agreement with kenya seed company, better and prompts payment to farmers and increased participation of farmers in day to day running of the scheme through the various organizations, steering committee, water Usser Association, advisory committee and co-operative society.
Contact person completing form: David M. Mburu
Contact details: Form filled by the consultant from information given by Mr. Ben Massawe, the scheme Manager, Perkera irrigation scheme.

Annex 13: Best Prctice Site (Wh) In Lare Division, Nakuru District

Date of Visit: 5/12/07	Category: BP site WH - Farm ponds
Name of Site: LARE DIVISION	Water Harvesting

Map of Lare division



Geographic location of practice: Lare division is about 200 Kilometres to the west of Nairobi city at an altitude of 2,234 metres above sea level.

(GPS) Coordinates: S 00º 27' 11.2" E 035º 59' 58.8"

Description of the Community: (Including no of beneficiaries; gender groups; number of households; names of villages; overall population; etc. According to 1999 population census the area has a population of 20,000 people.

Characteristics of the area: The area has undulating topography with gentle and steep slopes.

Climate (AEZ) + Description: There are four AEZ UM4, UM 5, LH2 and LH3,

Average annual rainfall (mm) 600 - 1000	
Months of Short Rains:	October - December
Months of Main	March – May

Rains:		
Mean annual ref. crop Evapotranspiration (mm):		
Predominant soil type:	Andosols and Nitosols	
Topography: Topography of the area is gentle slopes		
Slope:	Between 5-20 %	
Erosion:	High erosion rates	
Period of year during which used: All year round	All year	
Period of year during which benefits utilised:	Six months	
Water Source: Farm ponds		
Cultivated area: More than 80 % of the area is under cultivation, mostly with annual food crops.		

Technical Description: There are three water harvesting systems, namely roof catchment and ground catchments for runoff water harvesting and in-situ rainwater harvesting systems. Most houses in Lare are roofed with corrugated galvanized iron sheets that provide suitable catchment for rainwater harvesting. Roof water harvesting is done at schools, churches and individual houses which have corrugated iron sheet roofs. The harvested water is normally used for domestic purposes. Runoff water harvesting for agricultural production through construction of farm ponds is the most prominent system in Lare.
Runoff water harvesting is done by constructing farm ponds and directing road runoff into the ponds. The farm ponds are multipurpose water conservation structures depending on the location and size. The water pond is constructed by excavating a depression, forming a small reservoir. The water harvested in the pond may last between 3 - 6 months after rains depending on the capacity of the pond and the rate of water abstraction.

Technical Details: The main components of a pond system are the catchment area, diversion channel, de-silting chamber (silt trap), storage reservoir and finally the delivery system. The most critical design parameters considered by the farmers in Lare are length and slope of the diversion channel. Most ponds are located just off the roads to ensure shorter channel lengths. Before runoff enters the pond, there is a sedimentation chamber designed to reduce the sediment load in the runoff getting into the ponds. This reduces the frequency of de-silting the ponds and maintains the design capacity. From the pond the water is drawn using different systems; bucket and rope system, treadle pump system or a combination of the two. The treadle pump delivers about 50-200 litres per minute depending on the pumping head and strength of the operator.

Useful in: Farm ponds are constructed both in high and low rainfall areas. However more ponds have been constructed in the arid areas than in the high rainfall areas due to acute water shortage.	**Limitations:** Construction of the ponds is high labour intensive and so the initial cost is high. The storage capacity of most ponds is too small to supply sufficient water throughout a long dry season that may occur. High evaporation losses are difficult to address in hot and windy climates characteristic of the arid areas. Reduced storage capacity due to siltation is made worse by a lack of efficient silt traps.
Geographical extent of use: Farm ponds have been constructed in most areas of Lare division and there is large potential for construction of more farm ponds.	**Effectiveness:** Farm ponds have been effective in meeting the water demands for the community in a number of months between the rainy seasons. Depending on the population and water demand, a typical farm pond would

	keep water for between 3 - 6 months. If there is no prolonged drought, it is possible that the stored water may last the community or household to the next rain season.
Other Sites where used: Farm ponds have been constructed off stream to store river water during the peak floods. This is in areas of seasonal rivers where other water harvesting structures may not be applicable. In Lare there are no perennial rivers. The water courses however receive high runoff flow during the peak of rain season. Such runoff can be stored in off-stream ponds for later use.	
Cost: Most farm ponds are constructed manually and the main expenses are hand tools and labour for excavation. A medium farm pond may cost about USD 1,500.	**Operation and Maintenance arrangements:** In operation and maintenance it is assumed that a community or individual take the responsibility for managing the pond. Operation entails balancing water demand and supply and scheduling abstraction. Maintenance entails prolonging the lifespan of ponds through routine maintenance, repairs and de-silting. It is advisable to minimize direct access to the pond to reduce contamination. A fence should be built around the pond to keep children and livestock out.
Benefits: Farm ponds are sited close to the homesteads to increase water availability to the household. Reduced walking distance to the water sources will save time that can be used in other development activities.	**Water User Association or User Group:** For individually owned pond, the owner has the sole responsibility of controlling water utilization and maintenance of the pond. For a community owned water pond, there is usually a management committee or elected people to oversee the utilization of the water facility. The pond can also be managed by a person hired by the community and paid a monthly allowance. The water users pay a nominal fee as agreed by the management for maintenance of the water facility. The water is used for domestic and community farming activities which include watering tree seedlings and limited fish farming.
Stakeholders and beneficiaries: The beneficiaries are either private individuals or the local community depending on the ownership of the pond. Since farm ponds are highly labour intensive the community participation at all stages of construction gives them a sense of ownership and willingness to maintain the facility.	**Enabling Environment:** There are no complications in designs and so can be easily implemented by the community and private individuals. Though Lare receives unreliable rainfall, the soils and sloping topography provides suitable environment for rainwater harvesting. The water ponds in Lare are competing effectively with other sources like boreholes and the seasonal rivers. There has been government support and other NGOs and Egerton University in extension services, and training of farmers in soil and water conservation, design and implementation of the water harvesting system.
Training support: Individual people and community self-help groups have been involved in construction of farm ponds. Local community is easily trained on identifying suitable areas for farm ponds development.	**Extension support:** The government through the ministries of Agriculture and livestock, Egerton University and NGOs has assisted communities where large ponds have been constructed to meet high water demands.

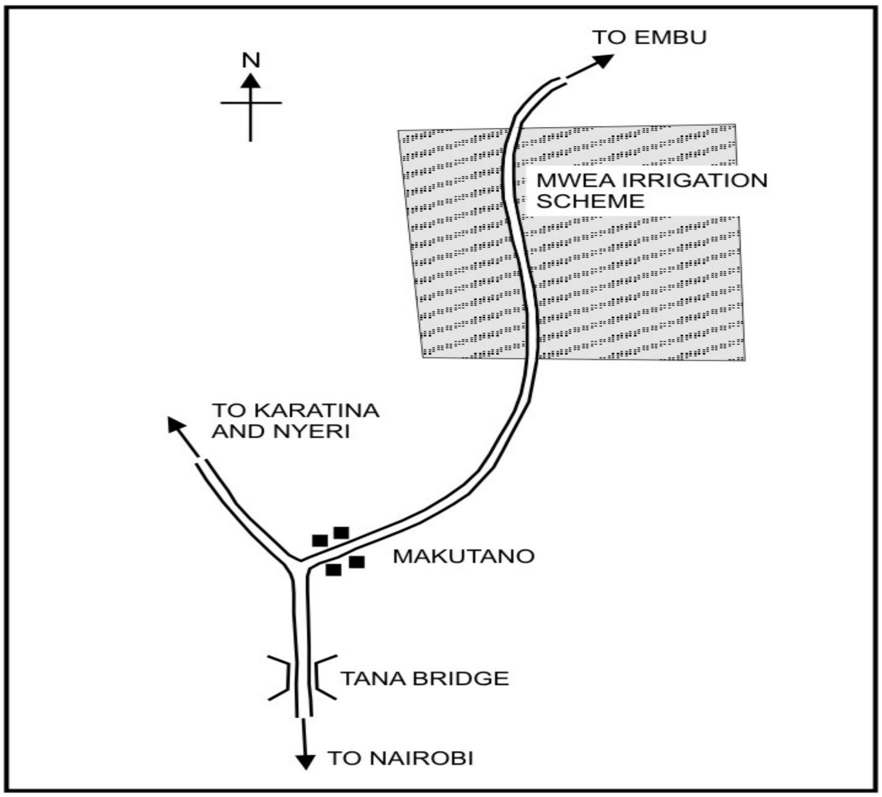
Environment benefits: Farm ponds have positive environmental benefits through control of surface runoff, ground water table recharge due to seepage, enhancing vegetation establishment in control of land degradation. Reducing the volume of surface runoff has controlled the rate of soil erosion. The ground water table recharge through seepage and deep percolation help in establishment of vegetation that has turned the area green and increased biomass production. Trees have increased availability of fuel wood which is in high demand. Trees have also helped to beautify the environment.	**Social/Cultural acceptability:** The practice has been accepted socially and culturally as a viable technology that has caused positive effected on the lives of many people and improved the standard of living.
Advantages: There is increased water supply to the community and individuals. The ponds are easily constructed because there is no demand for construction materials apart from hand tools and local labour. They can be constructed in any environment where the soil conditions are suitable for retaining much water with minimum seepage losses. The adoption of RWH in Lare has significant socio-economic and environment impacts in the area. RWH has reduced drudgery and time spent in fetching water hence releasing the girl child to participate in other productive socio-economic activities including school attendance.	**Disadvantages:** Farm ponds have the problem of breeding mosquitoes and increase the incidence of malaria outbreak. Open ponds are risky for children and animals if not protected by fencing around. There is high risk of contamination either by the condition of the catchment or the form of water abstraction from the pond.
Scaling Up: Most of the households in Lare division have RWH ponds. The adoption of rainwater harvesting in Lare has been enhanced by numerous trainings, excursions and extension packages offered by both local and international NGOs and government institutions. The farmers who have done very well in water harvesting systems in Lare have attended trainings at Baraka Farmers Training Centre in Molo. They have also gone for organized education tours to other areas like Machakos and some parts of western province. Most of the ponds individual initiatives but there are a few community water ponds.	What is potential for applying all/parts of initiative elsewhere? (Score from 1 to 10 on list below with 10 being highly applicable) I [8] Transfer of practice to another group/culture/land-use system, etc. II [8] Easy to transfer the practice, but with minor adaptations for local conditions III [6] Transfer possible, but significant modifications/prerequisites to consider. IV [3] Difficult to transfer the practice. Need experienced support. V [1] It would be impossible to transfer the practice. Too site specific.
Best Practices: (Why this site/ case is considered to be a successful best practice; express this success in qualitative or quantitative terms; whether all or only part of the practices of the site can be conidered best Practice - name them and give reasons why and provide any Conclusion and Recommendations):	

Since the practice was initiated 10 years ago the level of poverty has gone down. Many farmers are able to produce enough food crops for domestic consumption and market. Farmers have also diversified in their production systems and incorporated enterprises like bee-keeping, dairy farming, vegetable production and agroforestry. There has been high income generation and people have raised their living standards by building beter houses and improvement in nutrition. Soil erosion has been minimized and land productivity has increased.	
Contact Organisation: (For further information; site visits' etc)	
Type of organisation:	Contact person: Professor Chemelil
[*] government organization [ ] private organization [ ] NGO &/or CBO [ ] international agency [ ] other:	Contact details Egerton University, Agricultural Engineering Department.
Lessons learnt: (at various stages of the realization of the works, describe any lessons learnt that would improve upon future similar interventions)	

Annex 14: Best Practice Site (Pmi) Mwea Irrigation Scheme, Kirinyaga District, Central Province

Date of Visit 04/12/07	Category: Best Practice site PMI
Name of Site: Mwea irrigation scheme	Public Irrigation

Sketch Map of Mwea Irrigation Scheme site



Geographic location of practice: 90 kilometres North east of Nairobi. Altitude 1,158 metres above sea level.

(GPS) Coordinates: S 00º 42' 23.3" E 37º 19' 53.2"

Description of the Community: (Including no of beneficiaries; gender groups; number of households; names of villages; overall population; etc Beneficiaries include 4,000 original tenants and their dependants.

Characteristics of the area: Lowland and relatively flat topography.

Climate (AEZ) + Description: (Sets the climatic context - Arid; semi-arid; humid tropics; Mediterranean - Influences the types of crops that can be grown): Semi-arid area

Average annual rainfall (mm); 900	
Months of Short Rains:	October -December
Months of Main Rains:	March – May
Mean annual ref. crop Evapotranspiration (mm):	
Predominant soil type:	Vertisols (Black cotton soils)

Topography:	Gently sloping
Slope:	North-west to South-east
Erosion:	Not a major problem
Period of year during which used:	All year round
Period of year during which benefits utilized:	All year round

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):

Water from two perennial rivers from Mt. Kenya catchment, Thiba and Nyamindi Rivers with reliable water supply.

Irrigated area: (Total annual and then by season (ha)) 7,500 ha

Method of water abstraction: (Pumped; gravity; artesian - Influences the pattern of supply and cost of irrigation water):

Gravity irrigation system.

Water delivery infrastructure: (Open channel; pipelines; lined; unlined - Influences the potential level of performance):

Open channel both lined and unlined 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 - Influences the potential level of performance).

Level basin irrigation system.

Major crops (with percentages of total irrigated area): (Sets the agricultural context. Separates out rice and non-rice schemes, monoculture from mixed cropping schemes):

Rice is grown in the whole irrigated fields.

Average farm size: (Important for comparison between schemes, whether they are large estates or smallholder schemes). 1.6 ha

Type of management: (Government agency; private company; joint government agency/farmer; farmer-managed - Influences the potential level of performance):

Joint management between government and farmers co-operative society.

Technical Description: (Please describe in about 250 words the background of the irrigation development, how it is used, how it achieves its objectives and its main purpose - For local markets; home consumption; regional or national markets; export):
Mwea irrigation scheme was started in 1956 by African Land Development (ALDEF) programme. The scheme was started by detainees during the struggle for independence. The scheme development has been

<table>
<tr><td colspan="2">in stages and the gazetted area is 30,350 acres (12,140 ha). A total area of 16,000 acres (6,400 ha) have been developed for paddy rice production. The scheme is fed by two rivers, Thiba and Nyamindi. The water is abstracted from the rivers by construction of weirs. Water distribution is by gravity through major canals, secondary and tertiary canals. The canals are both lined and unlined depending on seepage losses and micro-relief of the area. Marketing of rice was initially done by National Irrigation Board (NIB) on behalf of the farmers. This has changed and the farmers are responsible for marketing their rice through the co-operative society.</td></tr>
<tr><td colspan="2">Technical Details: (Describe the studies that were carried out before implementation, any design manuals or guidelines that were used for implementation, Relevant Reports and Design Data used in Designs, and any major calculations made including runoff, available water supplies irrigation area or number of people supplied with water etc.):

Hydrological survey involving river discharge, water quality. Land use survey involving soil survey and land use practices incorporating soil genesis, mechanical, physical and chemical properties of the soil. Land capability survey including suitable crops, soil testing. Farm economic survey, Marketing survey. Topographical survey involving leveling. Meteorological survey including data on rainfall, temperature, relative humidity, evapotranspiration, wind speed.</td></tr>
<tr><td>Useful in: Describe the types of area where it can be used, the conditions where it produces good results, Sites of applications, etc.):

Area with gently undulating relief. Land which has flat terrain. Areas with black cotton soils (vertisols), Availability of water for irrigation</td><td>Limitations: Describe the conditions or situations where it does not perform well and conditions that will restrict its wider application where land is in a steep area):

Red soils or sandy soils with high infiltration rate. Semi-arid areas with no adequate water source.</td></tr>
<tr><td>Geographical extent of use: The areas of the study country where it is found and the sort of areas where it could be used within the Nile Basin):

Any other area with similar site characteristics like Mwea division, Kirinyaga district in central province.</td><td>Effectiveness: (Describe whether it has achieved its objectives, how well it has done and the general strengths of the practice and whether it has in fact achieved what it set out to do):

The objectives of the scheme have been met by producing more than 25,600 tonnes of paddy rice per year.</td></tr>
<tr><td colspan="2">Other Sites where used: Ahero irrigation scheme and West-Kano irrigation schemes in Nyanza province within the Nile basin</td></tr>
<tr><td>Cost: (If possible, and applicable, please indicate the total budget for the best practice, the sources of funding, the implementation period, the total cost and cost per cubic metre of watre stored or per ha irrigated, beneficiary contributions, etc.):
The beneficiaries pay operation and maintenance cost for irrigation water supply of Kenya shillings 2,000 per year. The farmers have to meet all the other production cost of ploughing, seed, fertilizer and labour for al operations.</td><td>Operation and Maintenance arrangements: (Who manages, operates and maintains the works, how this is funded, contributions levied per user, percentage of payment received against amounts requested, any assistance and support received from Government or other organizations, etc):

NIB manages and maintains water distribution system at the intake and major canals. The farmers manage and maintain the branch canals and the line canals to the farms. The farmers pay operation and maintenance</td></tr>
</table>

	cost of Ksh. 2,000 to NIB. The payment is over 90 % of the expected amount per year. The government assists in provision of heavy machinery and vehicle for operations.
Benefits: (Estimate the returns achieved from the site if involves irrigation or costs saved in getting water if water for humans or livestock): The water is also used for domestic and livestock. During the off-season of rice production, the water is also used in horticultural farming.	**Water User Association or User Group:** (Provide details of the type of organization, how it works and elects members, number of members and all other pertinent details): Water Users Association is very active in irrigation water management. The scheme is divided into eleven major units according to the major canals. The farmers elect one leader per unit to form an apex body of 11 people. The apex body and NIB form water management committee which distributes irrigation water. There are unit leaders of branch canals and line leaders who manage the water distribution to the farms. The system has been working well.
Stakeholders and beneficiaries: (Who are the main initiators, actors, stakeholders, beneficiaries and users? How and why are they involved in the practice? Actual level of beneficiary involvement under operation): The government initiated the project. There has been assistance by the Japanese government in improvement of water distribution system through renovation of intakes, canals and divisional boxes. Farmers are the major beneficiaries and contribute more than 80 % of the scheme operations. The stakeholders include NIB, Japanese government, Farmers co-operative society, Rice millers.	**Enabling Environment:** (Policies, design standards and manuals that made the concept possible, where the community obtained the idea, was it demand based or introduced by Government or private sector initiatives, etc.): The scheme was introduced by the government.
Training support: (Details of any training carried out before, during and after construction and how the community has benefited from this): There has been continuous capacity building to farmers and their leaders.	**Extension support:** (Details of any extension services provided and whether any help is given in assessing annual O&M needs and preparing costs and how the community has benefited from this): The government through NIB has been assisting in training community leaders in operation and maintenance.
Environment benefits: (Whether it has been completed as part of part of watershed development or integrated management approach, how it fits in, visible benefits achieved in terms or water availability, reduction in erosion, vegetative growth etc):	**Social/Cultural acceptability:** The scheme is 90 % appreciated by the community.

<table>
<tr><td>Basin irrigation helps in ground water recharge.</td><td></td></tr>
<tr><td>Advantages: (Strengths of the approach adopted, how well it fits into the community and meets its needs, is it affordable and replicable, will the community continue to operate, maintain and use it after outside assistance has gone and reasons for this etc.):

With 100 % payment of operation and maintenance fee by all land users through Water Users Association the scheme operations can be sustained.</td><td>Disadvantages: (Constraints that restricts its effectiveness, the risks involved in its developments, the conditions under which it will not work or have reduced impact etc.):

Non payment of operation and maintenance fee by some farmers.</td></tr>
<tr><td>Scaling Up: (Are there specific conditions or obstacles which make it impossible to replicate or transfer the practice elsewhere - e.g., a specific climate or specific cultural beliefs or social relations which are important for the success of this practice ;):

Areas with different characteristics from that of Mwea may be difficult for replication. The social factors also need to be considered.</td><td>What is potential for applying all/parts of initiative elsewhere?
(Score from 1 to 10 on list below with 10 being highly applicable)

I [5] Transfer of practice to another group/culture/land-use system, etc.
II [10] Easy to transfer the practice, but with minor adaptations for local conditions
III [7] Transfer possible, but significant modifications/prerequisites to consider.
IV [3] Difficult to transfer the practice. Need experienced support.
V [1] It would be impossible to transfer the practice. Too site specific.

Other specific remarks: (e.g., agreements, regulations, provisions regarding Intellectual Property Rights, etc.)

Provision to be within a legal framework</td></tr>
<tr><td colspan="2">Best Practices: (Why this site/ case is considered to be a successful best practice; express this success in qualitative or quantitative terms; whether all or only part of the practices of the site can be considered best Practice - name them and give reasons why and provide any Conclusion and Recommendations):

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.</td></tr>
<tr><td colspan="2">Contact Organization: (For further information; site visits' etc)</td></tr>
<tr><td rowspan="2">Type of organization:
[*] government organization

[ ] private organization</td><td>Contact person: Mr. Simon Kamundia</td></tr>
<tr><td>Contact details: Scheme manager Mwea Irrigation Scheme. P.O. Box 80, Wanguru. Tel. 06048004. Fax. 06048424 Mobile.0722621806. Email skamundia@yahoo.com</td></tr>
</table>

[ ] NGO &/or CBO [ ] international agency [ ] other:	

Lessons learnt: (at various stages of the realization of the works, describe any lessons learnt that would improve upon future similar interventions):
Planning: Involvement of all stakeholders in the project area through consultations, co-ordination and communication.
Design: There are two major extension areas already in place covering1, 200 ha. The government is assisting in construction of water channels and water control gates. The scheme activities are followed according to the design.
Construction: Use of locally available materials and trained personnel in the fields of engineering, quantity survey, material engineer, economists, agronomists and sociologists.
Implementation: Use of technically qualified people in construction and maintenance of the irrigation facilities.
O&M: Training of staff members on operation, control and maintenance of irrigation facilities and production processes. Routine/preventive operation and maintenance should be embraced rather than curative
Beneficiary involvement: Beneficiaries should be actively involved in decision making and day to day running of the project through their elected leaders. This will raise their sense of ownership of the scheme for sustainability.
Realization of benefits: (Such as markets; achieving better returns - crop selection &/or market linkages etc): Strengthening the management of farmers' co-operative society will improve their bargaining power in marketing and accessibility to credit.
Other Remarks or observations: To achieve the best practice, you require regular consultation, coordination and communication amongst all stakeholders.
Contact person completing form: James Mugo
Contact details: P.O Box Wanguru

Annex 15: Proceedings of One Day Validation Workshop on Best Practices in Water Harvesting and Irrigation Held on 20th March 2008

Introduction:

15.1.1 Welcome Address**;**
The Nile Basin Initiative (N.B.I.) acting National Project Co-ordinator (NPC), called the workshop to order at 11.00am; following a coffee/tea break. He welcomed all participants to the workshop.

Prayers;

Prayers were said by Dr. David Mburu.

Introduction of Participants;

The session chairman asked all participants to self introduce themselves. The list of participants is contained in Annex 1.

Brief on NBI-EWUAP project

Brief from PMU

Due to the need to concentrate on the core business of the workshop, i.e. presentation of best practices on water harvesting and irrigation by the consultant, the Project Management Unit Co-ordinator, Mr. Vincent Kabalisa gave a very brief introduction on NBI Project.

He said that the project is funded by the World Bank and the participating countries comprise of all the 9 (nine) Rive Nile riparian countries; namely – Kenya, Sudan, Rwanda, Uganda, Egypt, Tanzania, Burundi and Democratic Republic of Congo and Ethiopia.

The project started in the year 2006 and is set to wind up by December 2008. Several riparian countries each hosts an Shared Vision Project (SVP) whose recommendations are to be replicated to other riparian countries. In case of Kenya, the project being hosted is the Efficient Water use for Agricultural Production (EWUAP) Project.

Remarks from the NPC

Eng. Hosea Wendot, the acting National Project Co-ordinator, thanked the workshop participants and asked them to help thrash out any issues that may come up in the course of the consultants' presentation. The main objective of the workshop is to validate the report findings prior to the preparation of the final country report. He informed the participants that the EWUAP project is generally of software type, whose outputs are to help in facilitating investment under the Subsidiary Action Programmes (SAPs).

He recognized the presence of Mr Mogusu, the Desk officer in the Ministry of Water and Irrigation Headquarters in charge of Transboundary Waters (Including the Nile) as well as Ms Rose Thuo of the Ministry of Agriculture and the Chairperson of the EWUAP Project Steering Committee.

He described to the participants the administrative structure of the NBI Project, whereby the Project Management Unit (PMU) is located at the NIB headquarters while there are 9 (nine) National Project Coordinators (NPC) in every river Nile riparian country where the project is being implemented. The PMU was represented in the workshop by Mr. Vincent Kabalisa who is the Lead Specialist.

The National Project Coordinator is Eng. J. P. Olum, HSC who is the General Manager of the National Irrigation Board (NIB). The responsibility of organizing the workshop had been delegated to Eng. H. Wendot, Principal Irrigation Engineer, National Irrigation Board.

The Project Steering Committee is headed by M/S Rose Thuo of the Ministry of Agriculture Headquarters.

15.1 Consultant's presentation:

Dr. David Mburu, the Consultant gave a detailed power point presentation draft report on the consultancy undertaken to: "Identify, list, document and describe best practices, profiles on best practices; prepare inventory of institutions for twining activities, and identify gaps in any existing guidelines in the areas of water harvesting and irrigation".

The report was presented in the following format:

- Introduction/background
- Rainwater harvesting systems
- Community managed irrigation schemes (CMI)
- Public managed irrigation schemes (PMI)
- Review of existing water harvesting and irrigation guidelines
- Potential institutions for capacity building and twining activities
- Conclusion
- Recommendations

The presentation was organized in three sessions according to the Terms of Reference as follows:
SEESSION I: Rainwater Harvesting
SESSION II: Community Managed Irrigation Schemes
SESSION III: Public Managed Irrigation Schemes
SESSION IV: Plenary

15.4 REACTIONS FROM THE PARTICIPANTS:

SESSION I: - Reactions on Rainwater Harvesting

(a) Eng. W. Onchoke;

He asked the Consultant to include;

i) Definition of main terms
ii) Photographs of actual best practices in rainwater harvesting
iii) The possible water amounts that can be harvested and stored by each best practice at various AEZ and the potential these practices hold.

iv) A mention on tied ridges
v) Other sources of water that can be harvested and stored, e.g. Budalangi flood waters.

(b) Eng. Omendi Peter;

i) Were the retention ditches left out among the in-situ water harvesting practices?
ii) What were the assumptions with respect to regional or AEZ application because every best practice is not universally applicable?
iii) Inclusion of rainwater harvesting classification flow diagram.

(c) Eng. Kabok;

i) Description of how the best practices are carried out by:
   a) groups of farmers,
   b) individual farmers,
   with respect to marketing, agronomic practices, structural elements and organization.
ii) While tackling the suitable sites climate and soil factors ought to be considered together, e.g. showing the common practices in an ecological zone/soil for different soil types, like sandy, clay and loam.
   From these considerations, the best practice ca be singled out and a detailed study mounted.

(d) Eng. Wendot**;**

Referring to page 7, he noted that the biological/vegetative salient features listed are mainly common on humid zones, whereas the structural salient features were common in marginal areas.
What is the relationship?

Consultant's responses on session I:

- On main terms definition, he said this will be attempted.
- Photographs will be included
- On tied ridges, the list is not exhaustive. He said that the retention ditches are common in small land plots, where these act as a COD and no suitable areas to direct the run-off or an existing waterway.
- The best practice technologies for RWH are zone specific. He referred participants to page 7, where sand dams are described to be common in the places where the geology yields lots of sand.
- On some salient features being associated with certain AEZ, the consultant explained that due to climate change, prolonged droughts are common even in humid zones and therefore water ways are useful to both dispose off run-off and a conduit for water storage. Also in humid zones there is more biomass production hence vegetative methods are common, whereas, in marginal areas pastoralism, termite damage, water scarcity, competition for stover with livestock and fuel wood leaves little vegetative cover for water conservation, hence structures are common.
- All other suggested material by the participants will be addressed in the final draft.

SESSION II: - Reactions on community managed irrigation (CMI)

(a) Eng. Kabuti;

Q. Please clarify whether the ranking on page 38 has been done using the ideal systems or the existing systems.

Comment: The ranking proposed does not capture water use efficiency for agricultural production with the weight it deserves.

(b) Eng. W. Onchoke;

Comments:

i) The categories and definitions of irrigation practices in Kenya can be obtained from updated irrigation typology from the Ministry of Water and Irrigation, i.e.

- Smallholder irrigation schemes
- Public/National irrigation schemes
- Private Irrigation schemes.

ii) The prioritization of best practices should be based mainly on how efficient you deliver the water from abstraction to the farm and on-farm water use.
iii) Ranking could be faulty since Mitunguu scheme in Imenti South District is known to be more efficient than Kibirigwi scheme in Kirinyaga.

(c) Eng. Kabok;

Q. Does the ranking subscribe to the most commonly used system or best practice?

Comment: Please indicate the pressure limits for the low and high pressure sprinkler and drip irrigation systems. A visit at Kibwezi Care Kenya supported irrigation is worthwhile.

(d) Mr. Vincent Kabalisa;

Q.1. Can the use of treadle pumps considered for assessment together with other technologies?
Q.2. What is the agricultural productivity tons/ha for the best selected practices?

Comment: There is a need to carry out mapping for the selected best sites in future assignments.

Consultant's Responses:

- That there was no time to pay visit to other schemes in various regions.
- Data is not readily available from most irrigation schemes. The available data is not accurate or not updated.
- The ranking criteria will be re-evaluated during group discussion.
- Further contacts can be arranged with Ministry of Water and Irrigation Headquarters and Kibwezi Care – (K) supported irrigation scheme.
- Low and high pressure systems could be referred to as gravity fed systems, and pump fed systems respectively.

SESSION III: - Reactions on Private/Public irrigation schemes

(a) Eng. W. Onchoke;

i) On manual reviews, existing water harvesting and irrigation guidelines, only the first manual meets the criteria.
ii) Capacity building training institutions, a few more could be added, i.e. Regional authorities e.g. LBDA, KVDA, CDA, etc.

(b) Kabalisa Vincent;

Q.1. On the issue of agricultural productivity and water use, is there available data that can be relied upon?
Q.2. How is the Agricultural productivity of private irrigation schemes of Naivasha compared to the other selected best sites?

(c) Mwago Gitahi;

Comments: The checklist of salient features is very appropriate – however, the rankings should receive differential weighting to emphasize the importance of some of the features.
The Typology commonly in use by the irrigation sector should be used in the report to ensure consistence.

Q. How does marketing contribute to best practice in RWH and irrigation schemes?

Consultant's Response:

- That the best practice site for RWH at Lare, has been described included the AEZ on page 31 of the draft copy.
- On annex 2, page 69 of the draft copy, gives the AEZs for the irrigation schemes.
- Marketing issues were not evaluated as salient features, though these are crucial. In the final draft, the marketing issues will be highlighted.

Generally, the consultant isolated three marketing systems within the irrigation schemes, namely;

i) Open marketing- found in Mwea scheme
ii) Contracted marketing style – in Perkerra scheme, where Kenya Seed Company supports and buys the Maize seed grown.
iii) Group marketing – common in Kibirigwi.

- Productivity of schemes is difficult to establish due to lack of data.
- Naivasha horticulture irrigation schemes are mostly pump fed irrigation private schemes that do not easily release technical data, unless through some authority e.g. WRMA.
- The manuals reviewed were not exhaustive; more may be added onto the list.
- The consultant promised to liaise with MWI headquarters on the manuals on irrigation and water harvesting.
- The RDA's will be included in the final draft as institutions that offer capacity building on rainwater harvesting and irrigation.

The participants proceeded for **Lunch Break between 1.40 and 2.30 pm**.

Thereafter, there was the **Discussion-cum-Plenary Session** from 2.40 to 4.00 pm.

Discussion Topic:

RANKING CRITERIA OF SALIENT FEATURES IN THE SCORING MATRICES FOR BEST PRACTICES IN RAINWATER HARVESTING, B.P. RWH SITES AND B.P. IRRIGATION TECHNOLOGIES AND SITES

15.5. PLENARY SESSION

Suggestions to improve prioritization on the matrices:

- That the salient features highlighted for every considered best practice in rainwater harvesting technology, should be categorized such that those with more weight, score higher points and vice versa.
- The best practices in rainwater harvesting technologies should be linked to the AEZs so as to ease referencing and replicability in any suitable region within the river Nile riparian countries.
- Some key criteria for selection of the best practice in community managed irrigation on page 38, i.e., efficient water use, water productivity and cost should be ranked highest.
- Suggested addenda on the criteria for selection of best practices in CMI on page 38;
  - Dependency on external funding.
  - Water productivity in Kg of biomass/ Litre of water.
  - Water quality.

- It was agreed that the AEZ be stratified in three major AEZs amalgamating few others in close proximity , e.g. AEZ 1,2,3 be classified as AEZ I, whereas AEZ 4,5 be classified as AEZ II and AEZ 6 and 7 be classified as AEZ III. This will ease the ranking exercise of the salient features within the conveniently redefined broad bath of AEZs especially with RWH situation

- Each of the RWH technology ought to be subjected to the matrix for selecting the best practice specific for the given AEZs, so that any of the riparian countries can borrow a leaf and replicate the suitable best practice.

- On table 9, the salient feature no 2- climate; will be omitted since all these will be captured in AEZs.

- Gravity drip irrigation is known to be most water use efficient system with over 95% application efficiency, hence should be ranked highest refer to page 39 table 14 and this fact will go in tandem with the aspirations of the EWUAP. The gravity basin is most preferred by most farmers but is not necessarily the best practice in terms of water use efficiency.

- On table 13 page 38, the water application and delivery criteria may not weigh the same score for both the drip irrigation and the gravity basin irrigation practices.

- While ranking the environment impact and the situation depicts a negative impact, then a negative score should be awarded.

15.6 Recommendations

1. The workshop participants were satisfied with the good document the consultant had delivered within a short time, despite hurdles of some unavailable and unreliable data got from various relevant stakeholders.

2. There is evident gross shortage of updated and authentic technical data from all stakeholders on irrigation and rainwater harvesting, however experts from the Ministry promised to avail more data on various irrigations schemes. The consultant was requested to approach and discuss with them

3. That the final report would be quite authoritative document if the consultant was extended consultancy period to liaise with the stakeholders on irrigation and rain water harvesting and validates the information to his best for the various situations.

Annex 15.7: List of workshop participants

No	NAME	TITLE	ADDRESS	TEL/FAX.	MOBILE	EMAIL ADDRESS
1	Mr. Hosea Wendot	Engineer	P.O. Box 4165 – 00200 Nairobi	254 20 2711380 254 20 2063209 Fax.254 20 2722821	254 722977617	engineering@nib.or.ke Wendo12@yahoo.com
2	Mr. Vincent N Kabuti	Engineer	P.O. Box 30372	254 20 2711380	254 721217132	vkabuyi@yahoo.co.uk
3	Mr. Wilfred O. Onchoke	Engineer	P.O. Box 49720 Nairobi	254 20 2713603	254 733643199	wonchoke@water.go.ke wonchoke@yahoo.co.uk
4	Mr. Omendi Moses Jura	Engineer	Maji House P.O. Box 49720 00100 Nairobi		254 722688752	omedimosj@yahoo.co.uk
5	Mr. Gatahi Mwango	Soil Engineer	JKUAT P.O. Box 62000 Nairobi		254 722365516	Gatahimwango03@yahoo.com
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Annex 15.8: Workshop Programme:

PROGRAMME FOR ONE DAY VALIDATION WORKSHOP ON BEST PRACTICES ON WATER HARVESTING AND IRRIGATION

Date: 20th March 2008
Venue: Lenana Conference Hotel, Lenana Road, NAIROBI.

TIME	SUBJECT	RESPONSIBLE	CHAIRPERSON
08:30-09:00 am	**Registration**	Secretariat	
09:00-09:10 am	Welcome and Introduction	NPC	NPC
09:10-09:30 am	Brief on NBI SVPs and EWUAP project	PMU	NPC
09:30-10:00 am	Brief on EWUAP project	NPC	PMU
10:00-10-30 am	**TEA/COFFEE BREAK**	All participants	
10:30-11:00 am	Presentation of Best Practices and Best Practice Sites (WH)	Consultant	NPC
11:00-11:30 am	Presentation of Best Practices and Best Practices Sites (CMI)	Consultant	NPC
11:30-12:00 noon	Presentation of Best Practices and Best Practices Sites P/PMI)	Consultant	NPC
12:00-12:45 pm	Plenary discussion	All participants	
12:45-1:00 pm	Formation of three discussion groups (WH, CMI, P/PMI)	NPC	NPC
1:00-2:00 pm	**Lunch Break**	All participants	
2:00-3:00 pm	Group discussions	All groups	NPC/Consultant
3:00-3:10 pm	Group I (WH)	Plenary (All)	PSC
3:10-3:20 pm	Group II (CMI)	Plenary (All)	PSC
3:20-3:30 pm	Group III (PMI)	Plenary (All)	PSC
3:30-3:50 pm	Way forward/recommendations	NPC	PSC
3:50-3:55 pm	Closing	TAC	NPC
4:00 pm	Tea/Coffee and departure		