Chapter 5

Potential of Dryland Farming in Kenya and Environmental Implications

Fuchaka Waswa and John Mburu

5.1 Introduction

With the arid and semi-arid lands (ASALs) accounting for more than 70% of Kenya's total land area, and supporting an increasing population of both humans and animals, investment in water resources development will be a critical research and policy agenda for national development. From 1998 to date, devastating droughts have been persistent in Kenya to the level of being declared national disasters. Drought events translate into severe soil moisture deficits, far below crop and pasture water requirements. Often this is followed by crop failure and hence hunger, famine, livestock deaths and general human suffering. By way of intervention, government has often responded by focusing on short term measures like appealing for food aid, which in essence is a reminder of urgent policy re-orientation that would make ASAL areas self-sufficient when it comes to guaranteeing people's basic needs like food. A look at previous drought incidences in Kenya seems to suggest that although such climatic phenomenon are stochastic, drought should be expected every after about 4 years (Table 5.1). As such planning for lasting solutions should be possible instead of addressing symptoms on a routine basis.

With more than 20 devastating drought events already experienced, yet no viable counter-strategy to date, Kenya seems to either lack the relevant policy framework and or necessary political will to implement workable solutions. This too calls for research into possible causes of inaction to inform future decision-making. Besides scarcity of water, the ASALS also exhibit inherent characteristics that make them fragile ecosystems deserving careful management options in order to maximise on their agricultural potential (Table 5.2).

Further, Barron and Rockstrom (2003) observed that contrary to conventional thinking, the dry lands are not absolutely deficit of water especially when it rains, but rather suffer from poor rainfall distribution and poor land and water management. As such, ASAL development is hinged upon an integrated approach that focuses on its inherent limitations.

Table 5.1: Drought Incidences in Kenya

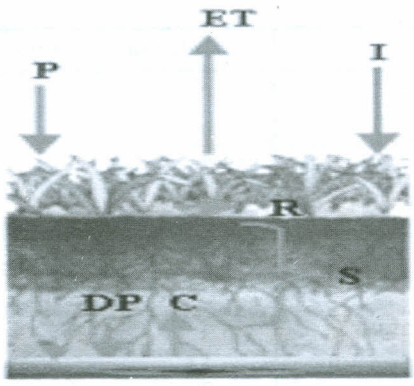
Date	Region	Interval (Years)
1883	Coast	-
1889-1890	Coast	6
1894-1895	Coast	4
1896-1900	Countrywide	1
1907-1911	Lake Victoria, Machakos, Kitui and Coastal	7
1913-1919	Eastern and Coast provinces	2
1921	Coastal areas	2
1925	Rift Valley, Central and Coast provinces	4
1938-1939	Northern, Rift Valley and Central provinces	13
1942-1944	Countrywide	3
1947-1950	Central and Coast provinces	3
1952-1955	Most of Kenya	2
1960-1961	Eastern, South/North Rift Valley	5
1972-1974	Widespread	11
1974-1976	Eastern, Central and Northern provinces	-
1980	Central, Eastern, Western, Coast	4
1981	Eastern Province	1
1983	Countrywide	2
1984	Central, R/Valley, Eastern, North Eastern	1
1987	Eastern and central	3
1992-1994	Northern, Central, Eastern provinces	5
1999-2000	Countrywide except west and coastal belt	5
2004-?	Much of country's ASAL areas	4

Source: Modified from UNEP, 2000

Table 5.2. Inherent ASAL Characteristics and Development implications

Characteristic	Implications
Low rainfall totals, erratic distribution, sudden severe storms, and high day temperatures	High costs when it comes to investment in water saving technologies
High soil erodibility tendencies, high salinity, very low soil organic matter	High costs of maintaining soil quality and stability in situ
Limited support infrastructure especially poor road and telecommunication network	Economic and political isolation, insecurity and reduced chances of commercial development
Generally high levels of household poverty	Limited per capita ability to participate in the development process.

The soil moisture budget (Figure 5.1) would provide a classical framework for planning in this regard, particularly when it comes to water saving strategies and other land productivity enhancing technologies.



I = Irrigation
R = Runoff
S = Storage
C = Capillary Rise
P = Precipitation
ET = Evapotranspiration
DP = Deep Percolation

$$S = I + P + C - ET - DP - R$$

Figure 5.1. The soil moisture budget with irrigation component

Conventionally the soil budget equation is represented thus: S=P-(R+ET+DP). In the dry lands (ASAL) change in soil storage (s) is normally less than crop water requirements (CWR). The consequent soil moisture deficit necessitates supplementing rainwater by other innovative water saving strategies and technologies. In dryland farming this can be achieved by among others irrigation technology, runoff (R) reduction technologies, prevention of evapo-transpiration losses (ET), reduction of deep percolation losses, and also increasing the soil depth to raise the soil's moisture holding capacity. The proceeding section of this chapter discusses some of these water saving technologies that have high potential to enhance community livelihoods in Kenya's ASAL agro-ecosystems.

5.2 Water Saving Technologies and Strategies

5.2.1 Water Harvesting

Water harvesting is the practice of collecting and storing water from various sources for productive purposes. When harvested from a watershed and conveyed to the ponds, dams or directly to a cropped area for storage and subsequent use, it can substantially increase water made available for garden irrigation, livestock water supply and other domestic agricultural needs. Instead of runoff being seen as a problem causing erosion, it is seen as a resource that can be taped and used for crop and livestock production, and even domestic purposes.

Conceptually, water harvesting refers to the induction, transfer and concentration of runoff onto man-made structures with the aim of increasing the effective rainfall and its storage as soil moisture so that it is available for crops for longer periods. Descriptions of water harvesting systems single out rain harvesting using within-field systems or micro-catchments, flood water harvesting or water spreading

from the water courses, and runoff harvesting using external catchments as the most common (Critchley et al., 1992). Typical characteristics of water harvesting have been outlined by (Young and Gowing, 1996). Rainwater harvesting is aimed at collecting runoff from a catchment area and concentrating it for use in a targeted area. The aim of rainwater harvesting is to capture and conserve the water as early as possible before it flows untapped into rivers, ground water or vanishes as evaporation. Essentially, rainwater losses through infiltration are prevented or minimised and runoff build up is enhanced through appropriate technology and strategies.

Importance of water harvesting

Water harvesting has become an increasingly important tool in the endeavour to improve crop yields in the arid and semi-arid lands (ASAL) of sub-Saharan Africa. To the society and farmers in these areas, water harvesting is important because it:

- Provides a strategic use of "free" water instead of going to waste into oceans
- Mitigates the impacts of drought and implications on livelihood
- Enhances water availability and eases demand for various purposes
- Enhances diversity of application in line with ever increasing competing uses
- Enhances access to quality water for good health and sanitation
- Supplements erratic and unreliable rainfall for agricultural purposes

Specifically in ASAL areas of Kenya, water harvesting has emerged as an appropriate technology that contributes positively towards improvement of annual and perennial crops' yields (Kiome and Stocking, 1995; Mburu, 1999), increased survival and growth rate of tree seedlings (Tiffen et al., 1994), and soil conservation and control of erosion (Critchley et al., 1992). Although the costs of applying water harvesting techniques are higher than with the normal tillage, Mellis et al. (1997) showed that it is a worthwhile investment as the marginal benefits were higher. Thus, water harvesting can lead to improvement of farmers' profits in ASAL areas and their standards of living.

The importance of rainwater harvesting in ASAL areas also stems from other sources of water being too costly or where wells are impractical to drill because of unfavourable geology or expensive drilling costs. Particularly in the eastern and northern eastern parts of Kenya water harvesting is important in ensuring food security to the ever increasing population as a result of immigration of farming households from the highlands (higher rainfall areas) in search of more agricultural land.

Conceptualising and Classifying Water Harvesting Systems

The conceptual perspective typical of all rainwater harvesting systems is shown in figure 5.2. Each runoff harvesting system is considered to consist of a catchment (collection) area (C) and a cultivated or concentration area (CA). The ratio between the two (C:CA ratio) is an important characteristic. Systems with a small C:CA ratio from 1:1 to 3:1 are typical for micro-catchments used for trees or contour ridges for annual crops. C:CA ratio is calculated from crop water requirement (CWR), expected (design) rainfall, runoff coefficient of the catchment area and an efficiency factor representing the proportion of rainfall harvested that is not lost through seepage, evaporation or overflow (Gowing et al., 2001). A catchment in rainwater harvesting constitutes the surface, which receives rainfall and contributes water to the system. It may consist of a paved area, open ground or temporary structures like sloping sheds. They include surfaces specially treated to harvest rainwater by reducing infiltration and enhancing surface flow. Conduits are on the other hand pipelines or drains that convey water from the catchment surface to the harvesting system.

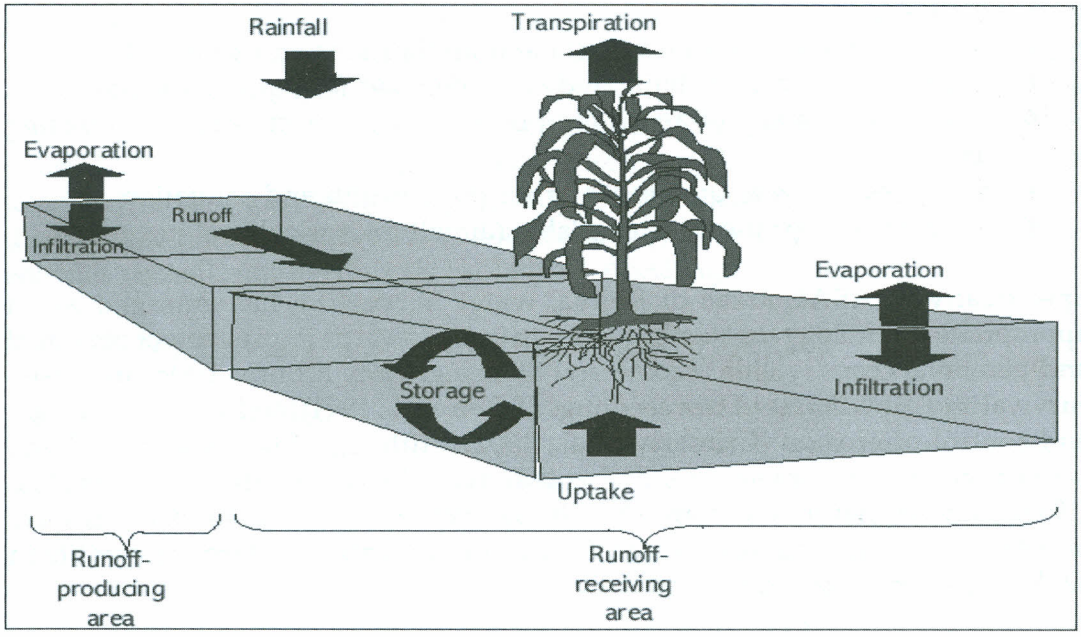


Figure 5.2. The hydrological components of a conceptual rainwater harvesting system Adapted from Gowing et al., 2001

A storage facility may be above or below ground with commonly used storage containers being masonry or plastic water tanks. Cleaning and disinfections are required to help maintain the quality of the stored water. A recharge facility is

required as an alternative to storage and involves charging rainwater into ground water aquifers through structures such as recharge pits and recharge trenches. Special attention must thus be given to catchment areas to enhance their tapping abilities. The quantity and quality of harvested water depends on the surface area of the catchment and its inherent properties: any modifications done are meant to minimise infiltration and maximise runoff. Catchment characteristics further determine storage types and potential water uses. Delivery of harvested water and its subsequent storage similarly requires proper environmental, technical, economic and social considerations.

A detailed presentation and classification of systems used to harvest, convey and eventually store rainwater in a water harvesting process can be found in Hai (1998) and Gould and Petersen (1999). For agricultural purposes, most of these have been classified as micro-catchments and macro-catchments. The distinction between these two classes depends on the length of the catchment (runoff collecting area) or the flow distance of runoff from the collection to the concentration area (sometimes the cropped area). Micro-catchments involve the use of within-field systems or structures to collect rainwater or runoff over a flow distance of less than 100 m from the cropped area and to store it for consumptive use in the root zone of crops (Mellis et al., 1997).

These systems include structures such as planting pits, planting furrows (contour furrows), tied furrows or ridges, cambered beds and negarims. Further, most of the indigenous water harvesting structures found in Kenya belong to this group. They include terraces, trash lines, stone bunds, grass strips and log lines. Macro-catchments involve collection of runoff from large runoff surfaces or slopes that are more than 100 m from the concentration or cropped area and directing it on onto a bunded area that is cropped in the usual manner (Hai, 1998). The macro-catchments are also termed as external catchments since the runoff collection area is normally located outside the cultivated or cropped area. Depending on the kind of harvesting surface, several rainwater harvesting systems can be distinguished (Figure 5.3), thus:

i. Roof catchments

These are the most common catchment types used for harvesting rainfall water for household purposes and home gardening. They are made of different materials e.g. galvanized iron sheets, corrugated iron sheets, plastic and tiles, thatched roofs, etc. Though they have other purposes, some may be built specifically for rainwater collection.

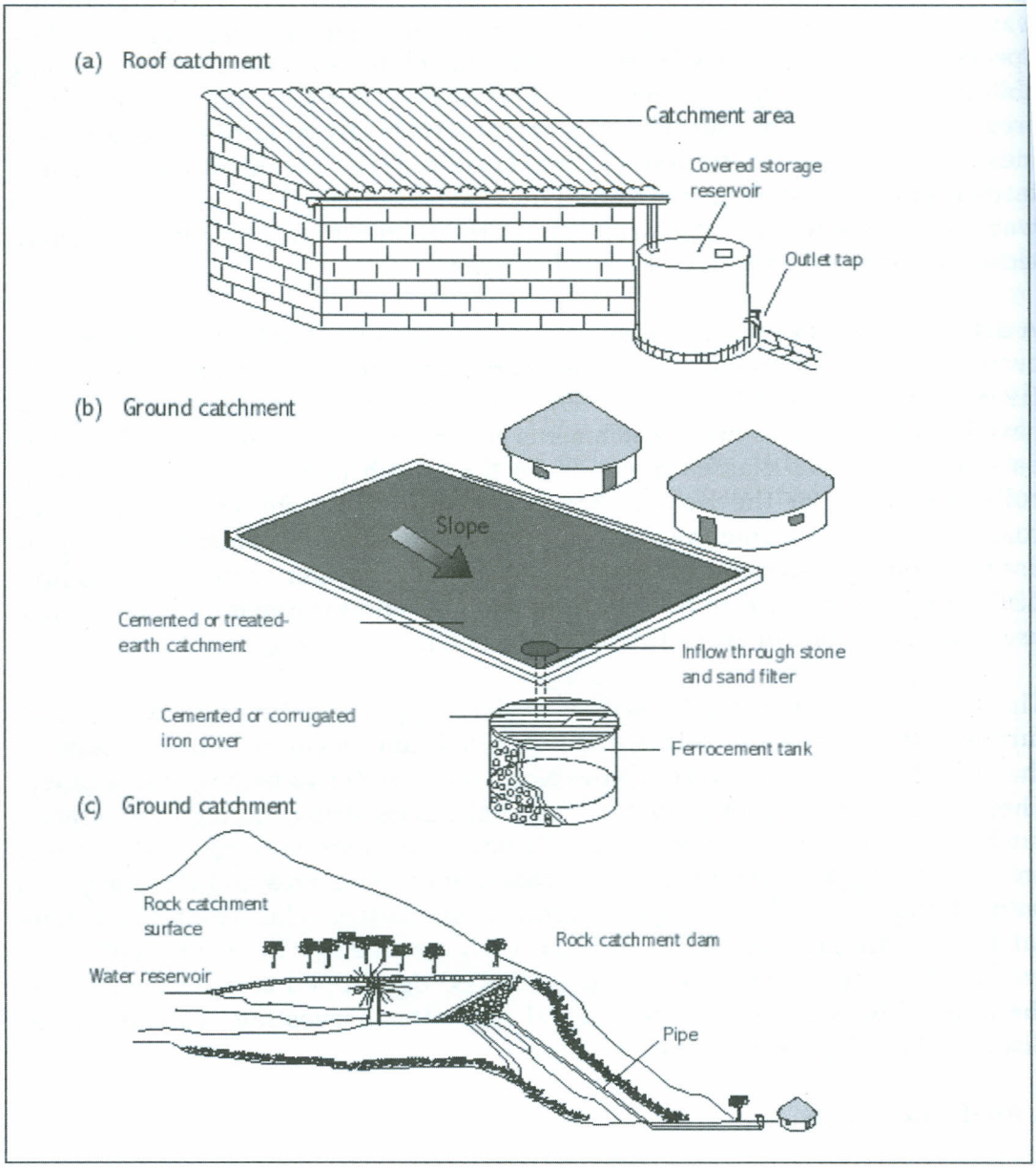


Figure 5.3. Rainwater catchment systems (Adapted from Gould and Nissen-Petersen, 1999)

ii. Ground catchments

These systems utilize ground surfaces as catchment areas. Alternatively referred to as land surface catchments, they include natural surfaces, road surfaces, pavements, courtyards, etc. which potentially provide useful runoff collection areas. The ground catchment provides opportunity for collection of rainwater from relatively larger areas than the roof catchments. However, water quality can be a challenge depending on the intended use.

iii. Rock catchments

Although technically a type of ground catchment, rock catchments are generally constructed in areas with suitable rock outcrops. Runoff from these rock surfaces is channelled along stone gutters constructed along the rock surface and into a reservoir contained in concrete or stone masonry dams.

iv. Storage facilities (tanks)

These are an integral part of any water harvesting system and could be above or below ground. Underground tanks must have pumping facilities, while above ground storage can save on costs by utilising gravity flow. Storage tanks are also made of different materials, which may be plastic, concrete and masonry, bricks and galvanised steel among others.

Environmental and Socio-economic Issues in Rainwater Harvesting

Collection of rainwater can be considered as promotion of energy conservation since the energy input required to run a centralized water system intended to treat and pump water over vast service area is replaced. Rainwater harvesting reduces local erosion and flooding brought about by runoff from impervious cover, which is captured and stored. In the city of Nairobi, Kenya, for instance, during heavy rains, the city streets are often flooded, with consequent costs like loss or damage to infrastructure and human lives. With urban rainwater harvesting, such runoff, though potentially contaminated due to urban pollutants, could be captured and utilized for several productive purposes. It would therefore provide good food for thought to policy makers to consider runoff management strategies by installation of rainwater harvesting systems.

Rainwater harvested from an appropriate roof catchment can be of a quality that almost exceeds that of ground and surface waters since it does not come into contact with soil and rocks. It does not dissolve salts and minerals and it is not subject to numerous pollutants which are often discharged into surface waters such as rivers and which contaminate groundwater. The quality of rainwater is also influenced by the environmental conditions of the targeted area. Rainwater that falls in areas that are not industrialized is superior in terms of quality than heavily polluted industrialized areas or agricultural regions characterized with crop dust.

Although rainwater harvesting can contribute to the improvement of livelihood of farming households living in the ASAL areas of Kenya, farmers in these area have not adopted water-harvesting techniques at a significant scale. As stated b Mellis et al. (1997), much research on surface water management for dry lan farming has been done by national and international research organizations, bu there has been little impact on farmers' subsistence production. Hai (1998) als indicates that there is little adoption of water harvesting in Kenya, a problen that is aggravated by the inadequacy of the methods employed in technolog development and dissemination. Most of the promotion initiatives of wate harvesting have been financed by international organizations and donors, man with the objective of choosing techniques that have been successful in othe countries and demonstrating that they can also work in Kenya. Often farmer are persuaded to adopt them after being provided with some incentives like tool (mainly fox, spade and wheelbarrow) and/or food for work.

These approaches have altogether turned out to be very inappropriate and farmer have not adopted water-harvesting techniques in large numbers. But the mai reason for this low adoption has been the tendency of "experts" to concentratio on technical issues of water harvesting such as structural designs without payin much attention to the problems that often arise in the dissemination an sustainability of the techniques. According to Mburu (1999), farmers are abl and willing to adopt water harvesting depending on a range of often interrelate socio-economic issues like land size and tenure, labour availability, availabl incentives, farmers priorities and participation, and realizable and perceive economic benefits. Critchley et al., (1992) underscore this fact and further stres that for any initiative of soil conservation and water harvesting to be successful the technical packages have to be attuned to local socio-economic aspects.

For farmers to adopt and benefit from water harvesting, recommended technique should be simple, cheap, low labour demanding, lead to appreciable yield increase in short-term and be grounded in the environmental knowledge and skills of th farmers (Kiome and Stocking, 1995; Mburu, 1999). Labour requirement has beer shown as the most important factor determining farmers' preferences for specifi techniques. If labour requirements for the techniques are very high, farmers wil not invest in them but will instead seek alternative ways of spending their tim and effort, e.g. in off-farm employment (Thomas, 1997). Scoones et al. (1996 point out that the issue of labour availability is often underrated and therefore often becomes a major constraint in the implementation stage of water harvestin initiatives. This is because it is normally assumed that family labour is almos freely available in ASAL areas, and particularly so during the dry season. However this is actually not always the case since other important factors such as bette off-farm incomes, women's domestic and reproductive responsibilities, and time demanding social activities have to be considered.

Water harvesting techniques in ASAL areas should also be designed in such a way that farmers adopt them without much of external support and incentive

like food-for-work and free tools. It is true that incentives and subsidies have a short-term role of altering behaviour of farmers and encouraging investment in soil and water activities (Critchley et al., 1992), but this may not be sustainable since farmers tend to switch to more cost-effective strategies once they are withdrawn. Thus the principal incentives should be acquiring of knowledge of appropriate water harvesting techniques through training, and achieving yield increases or profitability of the techniques.

Emphasis should be placed on indigenous water harvesting techniques since, compared to the modern ones, they have lower labour requirements, higher yields and do not have sustainability problems. For example, through their indigenous knowledge farmers in ASAL areas of Kenya have been using the trash lines for decades. Although for too long these techniques have been overlooked or ignored or seen as 'primitive' or 'rudimentary' (as opposed to the 'sophisticated' or 'modern' techniques) by Kenyan soil and water researchers, extension personnel and even NGOs, they are increasingly being recognized as having an integral role in the development of sustainable water harvesting technology (Scoones et al., 1996). Because of their importance, many soil and water specialists have emphasized that these indigenous techniques and local environmental knowledge should form the starting point of the development of sustainable water harvesting systems (Critchley et al., 1992; Scoones et al., 1996).

Issues of land ownership and the right of use cannot be ignored as they are known to affect adoption of soil and water activities in ASAL areas. This is because in many of these areas land is either owned communally or is subdivided but farmers do not have land title deeds (Mwarasomba & Mutunga, 1997). Security of tenure would be important to farmers since it would induce increases in investments of water harvesting by allowing farmers to be more certain of reaping water harvesting benefits in the future and also affording them better access to credit.

In the introduction of appropriate water harvesting techniques, participation of local farmers may have a direct effect on successful implementation of water harvesting initiatives in ASAL areas. Although it is now widely recognized that the "top-down" approaches to soil conservation and water harvesting activities cannot work with small-scale farmers most initiatives in Kenya continue to be of top down nature, with soil and water specialists and extension personnel determining which techniques should be introduced and the modalities of implementation. Participation in this case is triggered by external supply of packages or messages rather than being demand-driven after farmers have identified their local needs and priorities. Often this has led to failure of water harvesting activities, as the techniques introduced to farmers are not compatible with the local socio-economic settings.

5.2.2 Irrigation Technology

Irrigation is the artificial application of water to soil to supplement inadequate rainwater and contribute to soil moisture towards meeting such purposes as crop

water requirements, pasture water requirements and grass water requiremer
The irrigation process involves investigation, planning, design, constructi
maintenance and operation of structures and channels for proper conveyance
water from the source to the point of application and includes runoff farmir
micro and manual irrigation (Obiero, 1996). The necessity for irrigation arises
a result of such factors as insufficient rainfall, non-uniform distribution of rainfa
the need to grow cash crops and to control water supply by applying water
crops as and when required. Irrigation types or methods are classified usual
based on the way the water is applied to crops. While technical details have bee
discussed by van Lier et al., (1999), among others, three types of irrigation systen
are generally distinguished (Figure 5.4) thus, surfaces, sprinkler (overhead) an
drip

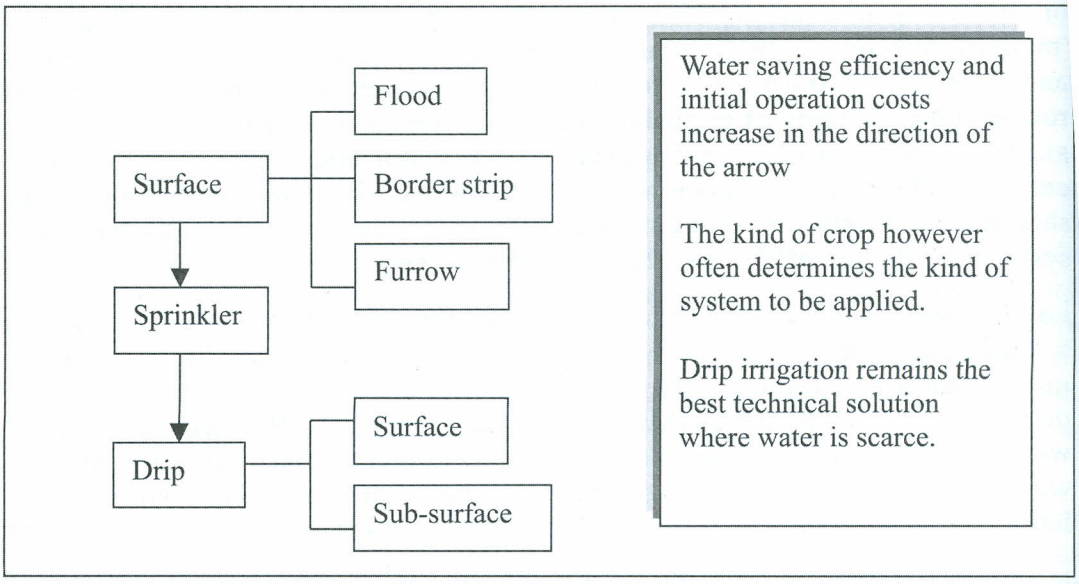


Figure 5.4. Conventional Irrigation types

Drip irrigation was designed to maximise on water saving by delivering water to
the crop root zone almost in exactly the amount the crop requires. Losses due to
evapo-transpiration, percolation and runoff are basically avoided. Sprinkler
irrigation mimics rainfall while in surface irrigation, water is allowed to flow on
the surface as it waters the crops. Another kind of irrigation, which could be
applied to drip, surface and sprinkler, is deficit irrigation. This is an optimising
strategy under which crops are deliberately allowed to sustain some degree of
water deficit and yield depletion.

The importance of irrigation technology includes among others the following:

- It supplements inadequate and unreliable rainfall particularly in the ASAL
- It can ensure all year production, hence food security

- Could be used to control pests and diseases by disrupting life circles
- Helps in the control of flooding and hence erosion especially where dams exist
- Could be used for strategic production as dictated by market forces
- Creates employment
- Could be used to reclaim more potentially productive land and hence create more settlement opportunities
- Specialised production targeting high value crops is also possible.

Extent of Irrigation Technology in Kenya

Globally, irrigated agriculture accounts for 40% of the food production, which comes mainly from approximately 260 million ha of irrigated lands, two thirds of which are under formal irrigation schemes (Malano and Burton, 2001). The irrigated lands account for only 20% of the cultivated land world over. Mbui (2000) points out that in many countries around the world, irrigation is taken seriously with many countries ensuring that a significant proportion of their arable land is placed under irrigation (Table 5.3). Evidently the proportion of arable land in Kenya under irrigation is comparatively much lower than in other developing countries. Noting that rainfall, especially in the ASAL, is erratic and unreliable, it is observed that there is need for professionals in agricultural sciences to intensively campaign and lobby the government to put in place a national irrigation plan targeted at increasing the arable land acreage under irrigation. This would partly be achieved by making use of the numerous water sources, which include the lakes and rivers that dot the land. It is of interest to note that East Africa hosts the second largest freshwater lake (Lake Victoria) in the world, but hardly benefits from its waters for irrigation because of the Nile treaty that was signed without Kenyans as stakeholders in the 1920s between the British and the Egyptians during the colonial period. In the meanwhile plenty of water from the Athi and Tana rivers is lost annually into the Indian ocean, perhaps never to be used again due to salinization.

Table 5.3. Proportions of arable land under irrigation in some selected developing countries

Country	Arable land (Ha)	Arable land under irrigation (Ha)	Percent (%) arable under irrigation.
China	111million	76million	68%
Egypt	2.8million	2.8million	100%
India	164million	38million	23%
Pakistan	21million	12.4million	59%
Kenya	10million	20,000	0.02%

Source: Mbui, 2000

5.2.3 Potential of Sewage use for Irrigation

The theory behind harnessing sewage water lies in domestic sewage comprisin more than 90% water and less than 10 % organic and inorganic solids compounds. Disposing this water in a country where water scarcity is a seriou problem would be inconsistent with sustainable use of scarce resources. This wate can be tapped and harnessed for a variety of human well-being purposes throug activated sludge treatment as has been successfully demonstrated in Israel (Figur 5.5). As an example of the potential of sewage recycling in Kenya, the Nairob Sewerage and Water System-RUAI is the largest in Kenya and the second larges in Africa. It has 36 ponds within an area of 200 ha. The maximum capacity of the facility is 80,000m^3/day. Current operation capacity is 45-60,000m^3/day. Waste treatment at the facility is mainly through biological and physical techniques.

Unfortunately, the treated water (secondary effluent), which can be used for irrigation on some limited crops is discharged and lost as drainage water through the Nairobi River. The Ruai treatment plant can be modified to include sand purification and chlorination to yield tertiary effluent, which can be used for irrigation on virtually all crops. In all cases the greatest environmental risks of using treated sewage for irrigation is pathogenic in nature, which thus demands for thorough treatment processes and adequate quality control.

Environmental aspects of Irrigation for ASAL Development

Irrigated agriculture often results into land-use changes and consumes significant quantities of fresh water therefore having significant impact on the environment. The common environmental impact of irrigation technology is soil salinisation. Although the extent of salinity in irrigated areas in Kenya is not yet quantified, several locations have been affected adversely such as Bura Irrigation scheme in Tana River, Taveta irrigation scheme, Vanga Irrigation scheme in Kwale and several irrigation schemes around Kibwezi. Lack of proper reclamation and prevention measures have resulted into some schemes being abandoned. Currently, with improved irrigation technology, poor performance of irrigation projects may be due to bad governance both at the political and farm level.

Other environmental impacts of irrigation technology include: water logging, soil erosion, seawater intrusion, water pollution and health problems, water conflicts due to competing uses, biological disturbances of aquatic life and loss of riparian habitats and change in water quality.

It is therefore important to recognize that despite the agricultural potential of irrigation technology, appropriate measures must be put in place to mitigate its negative environmental impacts. Readers are encouraged to put emphasis on this section. The serious concern of water related projects necessitate that

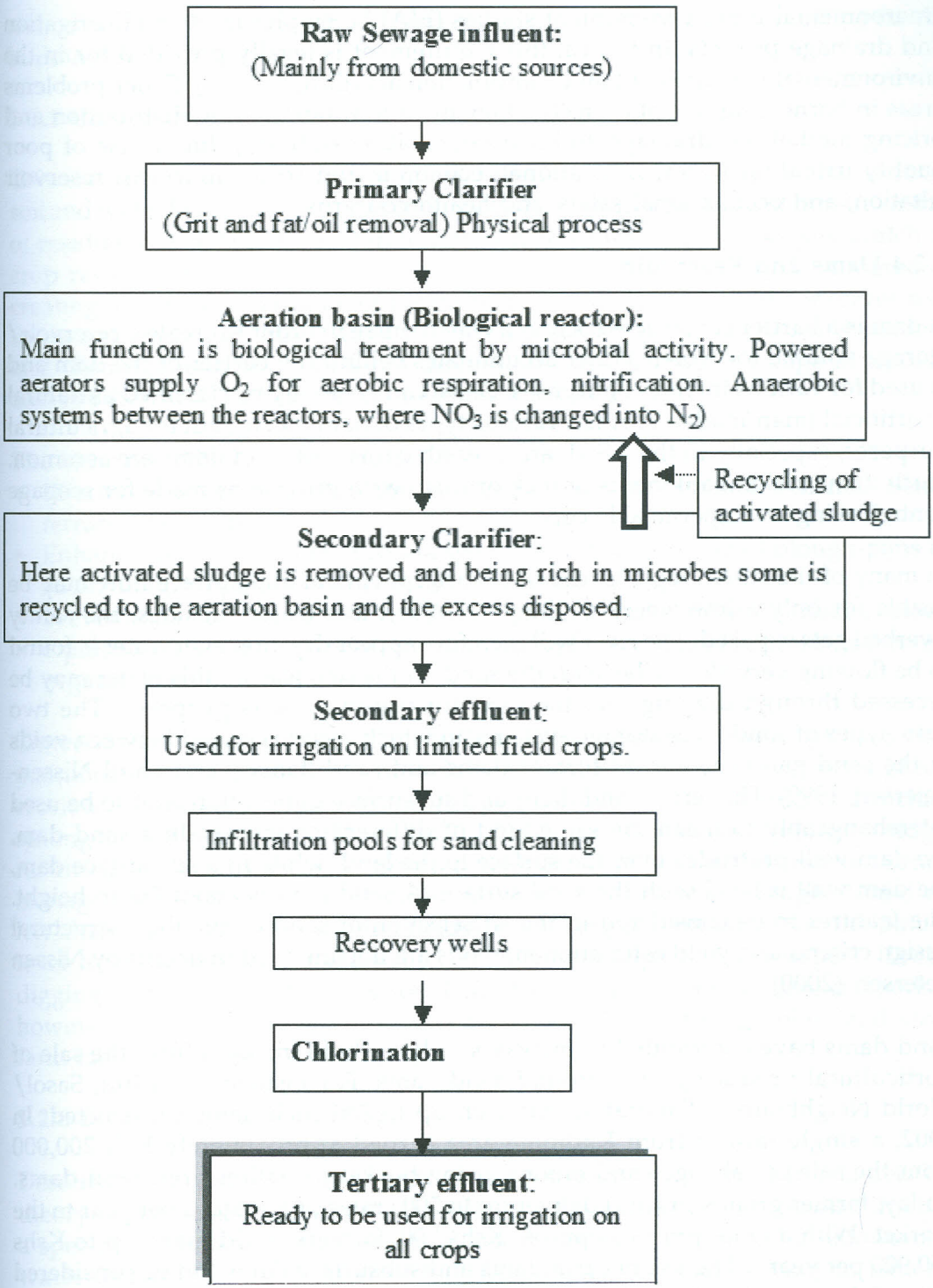


Figure 5.5. Simplified illustration of sewage treatment as is done at Shafdan treatment plant, Israel (Courtesy of Mashav: International course on Agriculture and Environment, 2005)

environmental impact assessment studies (EIA) be emphasized on all irrigation and drainage projects. In Kenya, this requirement is legally provided for in the environmental management and coordination act (EMCA, 1999). Other problems areas in harnessing irrigation technology include water quality, distribution and pricing modalities; drainage and soil degradation (salinity) due to use of poor quality irrigation water; institutional, economic and social concerns; reservoir siltation; and occupational safety and health concerns.

5.2.4 Dams and Reservoirs

A dam is a barrier constructed across a watercourse in order to create a reservoir/storage volume for water. Water accumulates behind the barrier of the dam and is used for various intended purposes. Dams can generally be classified as natural or artificial (man-made). Further, various types of dams occur, but for agricultural purposes, especially in the ASAL areas, earth dams and sand dams are common. Earth dams are embankments of rock or earth with provisions made for seepage control using an impermeable core.

In many of the ASAL regions, the rivers are ephemeral and surface flow may be visible for only a few weeks of the year. When this water subsides, the sandy riverbed gets exposed. The river will therefore appear dry, however water is found to be flowing very slowly beneath the sand. In the dry season, this water may be accessed through digging into the sand for use in various purposes. The two basic types of sand river storage systems, in which water is stored between voids in the sand particles, are subsurface dams and sand dams (Gould and Nissen-Petersen, 1999). The terms sand dams and subsurface dams often tend to be used interchangeably to mean the same kind of different structures. In a sand dam, the dam wall protrudes over the surface to the land, while in a subsurface dam, the dam wall is level with the sand surface. A sand dam is about 2m in height. The features to be considered in the sit selection of sand dams, their structural design criteria and yield estimation methods are documented in details by Nissen Petersen (2000).

Sand dams have contributed to increases in household incomes from the sale of horticultural produce grown around sand dams. For instance, In Kitui, Sasol/World Neighbours collaboration has seen up to 280 such dams constructed. In 2002, a single farmer from Kathome area earned approximately Ksh 200,000 from the sale of cabbages and onions, using bucket irrigation from sand dams. Today, farmer groups in Kitui deliver up to 500 crates of tomatoes per year to the market. With a crate price of approx. Kshs 700, farmers could make up to Kshs 350,000 per year[17]. The use of earth dams and subsurface dams can be considered as useful storage methods in rainwater harvesting technology. Developing this

[17] *Interview with Mr Kitema and Mr. Munyoki of Sasol (Sahelian Solutions)*

technology would thus imply deliberate measures to limit sand harvesting for the building industry.

5.2.5 Conservation Tillage

Conservation tillage (CT) is any tillage operation, system, practice that reduces soil and water loss relative to conventional tillage, often in the form of non-inversion of residue mulch. It has an operation threshold of leaving at least 30% mulch or crop residue on the surface throughout the year (Ngigi, 2003). It is aimed at creating a suitable environment for growing a crop in a way that conserves soil, soil water, and nutrients. It aims at long term sustainability of the soil's physical and chemical fertility. A detailed discussion of conservation tillage in Eastern and Southern Africa has been done by Biamah et al. (2000).

The basic principles of conservation tillage are:

- Effective soil erosion control through such measures as diversion ditches, bench terraces, grass strips etc.
- Enhancement of soil moisture storage through the breaking of plough-pans by sub-soiling, ripping and chiselling operations.
- Prevention of excessive soil pulverisation, soil sealing and soil surface crusting
- Optimal fertility management e.g. through replenishment of soil humus through organic farming practices.

Conventionally conservation tillage is characterised by three main objectives, thus maintenance of soil fertility, conservation of soil moisture, and control of soil erosion. Examples of conservation tillage practices are expanding and include among others minimum tillage (MT), *Tied-Ridges* (cross-connecting of ridges resulting in small basins or micro-catchments for water harvesting, runoff management and erosion control), *strip cropping* (strips of unploughed land are left alternating with the cropped fields), *sub-soiling* (i.e. tilling below the plough level to break the hard pans, which tend to develop at 15 cm depth), double digging, *deep tillage and sunken seed beds*. The sustainability of these methods is however influenced by various factors such as climate, topography, land sizes, farm labour dynamics and crop type.

5.2.6 Potential of Desalination

Desalination of seawater is already a success story in countries like Israel. The theory behind desalination is *reverse osmosis*, where saline water is passed through a special membrane at high pressure, which restrains the salts, but allows only water to pass through (Figure 5.6). The potential of desalination in Israel is estimated at 400 MCM/yr. The cost of half a dollar per cubic metre is rather prohibitive currently. The challenge to tap into vast quantities of ocean and

seawater is thus to research into cost effective desalination technologies. Another environmental problem is how to deal with the brine (concentrated sodium chloride) as the main by-product

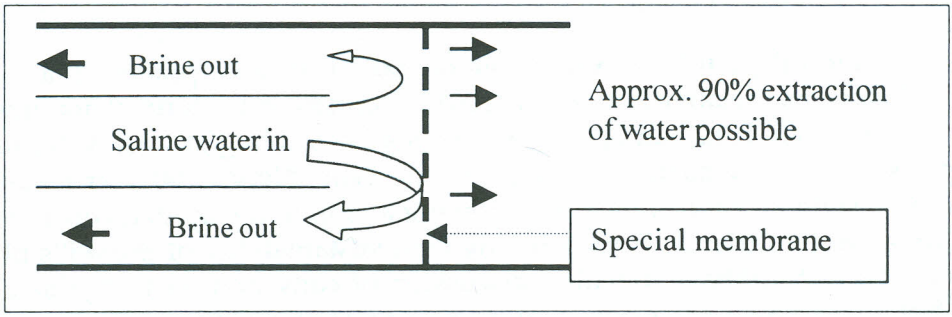


Figure 5.6. Illustration of Desalination

Kenya too has vast quantities of saline ocean water, with surrounding coastal areas experiencing frequent drought and food shortages. Though perhaps not feasible in the short term due to cost implication, planning to tap this vast amount of water for the future should start. A desalination research and technology development centre would be a worthy investment for universities.

5.2.7 Other Critical Water Saving and Management Options

Besides investment in appropriate technology, other water saving strategies being aggressively practised around the world, and which could be done in Kenya include:

i. Nationalising Water Resources

Being a form of natural capital, all water sources (surface and underground) are by law public property in Israel and use is controlled and regulated by government to maximise the common or collective good. In Kenya such legislation would be instrumental when it comes to saving water from overuse by private companies, particularly for flower production at the expense of surrounding farming communities.

ii. Pollution Prevention

Pollution reduces availability of good quality water and so contributes to water scarcity. Polluter-pay principle by imprisonment and not cash bail has proved effective in Israel. Mechanisms for water quality monitoring and assessment remain vital tools that government could employ to safeguard its water resources.

iii. Water Pricing

Water pricing is essential because people always tend to misuse free things (whether goods or services). Effective pricing instils some degree of accountability and efficient use of resources, when pricing is pegged on unit volume used. Since flat rate metering is often not effective in water saving, water pricing must be regulated by appropriate legislation.

iv. Aggressive Domestic Conservation Policy

This could entail such approaches as reducing leaking loses and water use in municipal parks through automated drip instead of sprinkler irrigation, installation of water saving devices such as regulators in faucets and showerheads and use of automated drip irrigation for gardens.

v. Watershed Management

The main objective of this multi-intervention option is to prevent, control or minimise soil loss from farmland and thus reduce sedimentation of water reservoirs. Reservoir sedimentation reduces their storage capacity, which could contribute to water wastage and scarcity.

vi. Control of abstraction from Underground Aquifers

The potential for underground water utilisation is high in Kenya. Investment in this technology has been however erratic and seems not to be government policy. With a water law in force, regulation of such abstraction should also be possible.

vii. Building Institutional and Human Capacity and Competence

To achieve sustainable water resources management, there is need to build support institutions and the necessary human capacity (know-how) and competence (do-how). Some critical aspects in this regard include technical training, administration and management of human resources, and ecosystem dynamics within the context of sustainable development.

viii. Behavioural Change among water users

Having the right attitude about water and also spontaneous propensity for accountable use is no doubt the single most important requirement for sustainable water management (use, care and improvement). For instance one does not have to use more than one litre of tap water to wash a teaspoon after using it to stir tea.

ix. Crop Technologies

Dryland farming could also benefit from careful investment in biotechnology and crop genetic engineering particularly in developing early maturing and water stress resistant crop varieties. Further, to lessen water demand and on-farm production pressure, investment in alternative food security measures like bee farming has proved effective in some marginal areas in Kenya (World Neighbours, 2000).

5.3 Conclusions

Water scarcity, and poor quality of the little that is often available, remain key hindrances to sustainable livelihoods in most ASAL communities. Investing in rainwater harvesting, tapping of ground water resources, harnessing sand dam, and building earth dams for storing surplus water received in the rainy season represent essential technologies critical in ASAL transformation. In the long run however, integrated approaches that utilise all possible water resources would be a positive step towards sustainability. Use of treated effluent and desalination of the vast amounts of ocean water represent future solutions in this regard.

5.4 Sample Questions

i. Critically examine the impacts of drought on the total environment and suggest possible mitigation measures within the Kenyan context.

ii. On the basis of its inherent characteristics, discuss a possible framework towards sustainable agricultural development for a typical ASAL agro-ecosystem.

iii. Discuss the various socio- economic variables that would be considered for a successful implementation of water harvesting activities in Kenya's ASAL environment.

5.5 Bibliography

Barron J. and Rockstrom, J. 2003. Water harvesting to upgrade small-holder farming: experiences from on-farm research in Kenya and Burkina Faso. Regional Land Management Unit, Nairobi, Kenya.

Biamah, E. Rockstrom, J and Okwach, G. E. (eds). 2000. Conservation Tillage for Dryland Farming. Technological Options and Experiences in Eastern and Southern Africa. Proc. of a Conservation Tillage Training Workshop held

from 22-26th November 1998. National Dryland Farming Station Katumani, Machakos. RELMA, Nairobi.

Critchley, W.R., Reij C.P. and Turner S.D., 1992. Soil and water conservation in sub-Saharan Africa. An IFAD report prepared by the Centre for Development Co-operation Services, Free University, Amsterdam.

Gould, J. and Nissen-Petersen E. 1999. Rainwater Catchment Systems for Domestic Supply. Intermediate Technology Publications. Southampton Row, London.

Gowing, J.W., Mzirai, O.B. and Young, M.D.B. 2001. The Parched Thirst Model Version 2.1, Tutorials.

Hai, M.T., 1998. Water harvesting. An illustrative manual for development of microcatchment techniques for crop production in dry areas. Technical hand book No. 16. RELMA/SIDA, Nairobi, Kenya.

Kiome, R.M. and Stocking M., 1995. Rationality of farmer perception of soil erosion: The effectiveness of soil conservation in sem-arid Kenya. In: *Global Environmental Change,* Vol. 5, No.4, pp. 281-295.

Malano, H. and Burton, M. 2001. Guidelines for Bechmarking Performance in the Irrigation and Drainage Sector. Food and Agriculture Organization Rome, Italy.

Mbui, A.M. 2000. Message from the Chairman (KSAE). Abstracts and Conference programme. Kenya Society of Agricultural Engineers (KSAE) Annual International Conference, Grand Regency Hotel, Nairobi. Kenya.

Mburu, J. 1999. Water Harvesting in Eastern Kenya: A Case Study of Socio-economic Influences in the Adoption and Sustainability of Techniques in Mbeere and Tharaka-Nithi Districts. Unpublished dissertation, University of Goettingen, Germany.

Mellis, D., Matsaert H. and Micheni A. 1997. Rainwater harvesting for crops in semi-arid areas. In: KANG'ARA et al. 1997, Participatory dryland agricultural research east of mount Kenya, pp. 142-161. DAREP, RRC, Embu, Kenya.

Mock, J.F. and Bolton, P. 1993. The ICID Environmental Checklist. International Commission on Irrigation and Drainage. HR Wallingford, United Kingdom.

Mwarasomba, L.I. & Mutunga K. 1995. Soil and Water Conservation Technology Development in ASAL- A Survey of Positive Experiences. NSWCP, SWC Branch, MOALDM, Nairobi.

Ngigi, S.N. 2003. Rainwater Harvesting for Improved Food Security: Promising Technologies in the Greatest Horn of Africa. Kenya Rainwater Association.

Nissen-Petersen, E. 2000. Water from Sand Rivers: Manual for site survey, construction and maintenance of seven types of water structures in river beds. ASAL consultants, Technical handbook No. 23. Regional Land Management Unit (publishers).

Obiero, J.P.O. 1996. Soil and Water Engineering Lecture Notes. Dept. of Agricultural Engineering, University of Nairobi, Nairobi, Kenya.

Scoones, I., Reij C., and Toulmin C., 1996. Sustaining the Soil: Indigenous Soil and Water Conservation in Africa. In: Reij C., Scoones I. & Toulmin C. (editors). Sustaining the soil, pp.1-27. Earthscan Publications Ltd, London

Thomas, D. B. 1997 (ed). Soil and Water Conservation Manual for Kenya. Soil and Water Conservation Branch, Ministry of Agriculture, Republic of Kenya, Nairobi.

Tiffen M., Mortimore M. & Gichuki F., 1994. More people less erosion: environmental recovery in Kenya, Overseas Development Institute. John and Wiley & Sons Ltd, England.

UNEP. 2000. Devastating Drought in Kenya. Environmental Impacts and Responses. UNEP, Nairobi.

van Lier, H. N. (ed). 1999. CIGR Handbook of Agricultural Engineering, Vol. 1: Land and Water Engineering. American Society of Agricultural Engineers.