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Contents

Acronyms

ASAL	Arid and Semi-Arid Lands
CBO	Community Based Organization
CGIAR	Consultative Group on Agricultural Research
Cordaid	Catholic Organization for Relief and Development
NEPAD	New Partnership for Africa's Development
ENNDA	Ewaso Ng'iro North Development Authority
GIS	Geographic Information Systems
GPS	Geographic Positioning Systems
IFAR	International Fund for Agricultural Research
ILRI	International Livestock Research Institute
IWMI	International Water Management Institute
LMD	Livestock Marketing Department
JKUAT	Jomo Kenyatta University of Agriculture and Technology
MoA&LD	Ministry of Agriculture and Livestock Development
MoW	Ministry of Works
MoWRD	Ministry of Water Resources, Management and Development
NGO	Non Governmental Organization
TLU	Tropical Livestock Unit
WRAP	Water Resources and Planning Project
WUA	Water User Association

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Executive Summary

There has been growing frustration with the pace at which relief and development efforts reach beneficiaries in drought-prone arid and semi-arid lands (ASALs) of East Africa, where 20 million people are in chronic need of famine relief, and poverty prevalence exceeds 60 percent of the population. This frustration reached its peak in the year 2000, when prolonged drought in the region saw the loss of about 50 percent of the cattle in certain vulnerable districts of Kenya, mostly due to lack of water. Relief agencies remained helpless lacking information to guide them at quick notice, as to the precise location of alternative local water sources to offset precarious stress levels in the most affected areas. At the end of the drought, stakeholders in certain ASAL districts decided to conduct rapid assessments and document the status and access to water by communities and livestock. In particular, the assessment was planned to capture strategic water sources for "drought-proofing." It was also agreed to link this information to Geographic Information Systems (GIS), while taking into consideration impacts on livelihoods. As livestock husbandry is the predominant economic activity in these zones, information on water for livestock is of paramount importance.

This report thus presents the results of a study to determine access to water sources by pastoral communities and their livestock in Isiolo District of Kenya, with special focus on water availability during drought conditions. The study was conducted between 2002 and 2003. It utilized GIS tools and information gathered through rapid assessments involving researchers, government officers, local communities and NGOs. Isiolo is an ASAL district in Eastern Province of Kenya, where pastoral livestock systems form the main economic activity, but water scarcity and recurrent drought are major constraints. From the study, GIS thematic maps were developed to include rainfall distribution, land use-cover, drainage systems, hydrogeology and grazing potential as well as types and location of water sources, their operational status and major characteristics.

The study determined that the total water demand for humans and livestock in the rural areas of Isiolo District is about 6,018 m^3 per day, which is equivalent to 2.2 million m^3 per year. Developed water sources are poorly distributed, amounting to 123 sources/points, of which only 44 (36%) are operational during the dry season. There is no piped/tap water in the rural areas and the district relies mostly on boreholes, accounting for 58 percent of all developed water facilities. This suggests an over-reliance on groundwater, yet only about 20 percent of the district area has good groundwater potential. Moreover, both supply and demand for water vary by season, with critical scarcity during the dry season, when about 93 percent of the district area lacks water sources for domestic supplies within 5 km distance, affecting 175 (73%) of the villages. At the same time, livestock lack access to water to within 15 km distance in about 63 percent of the area, affecting 92 (38%) of the villages. During the dry season, in areas such as Merti, Garbatulla and Sericho some of the people undergo hardships as their villages are located 50-75 km from the nearest water point. Other constraints include siltation of pans, recurrent droughts, lack of fuel to run boreholes, poor infrastructure, overgrazing and degradation of areas around water points, high poverty prevalence and lack of community water management institutions.

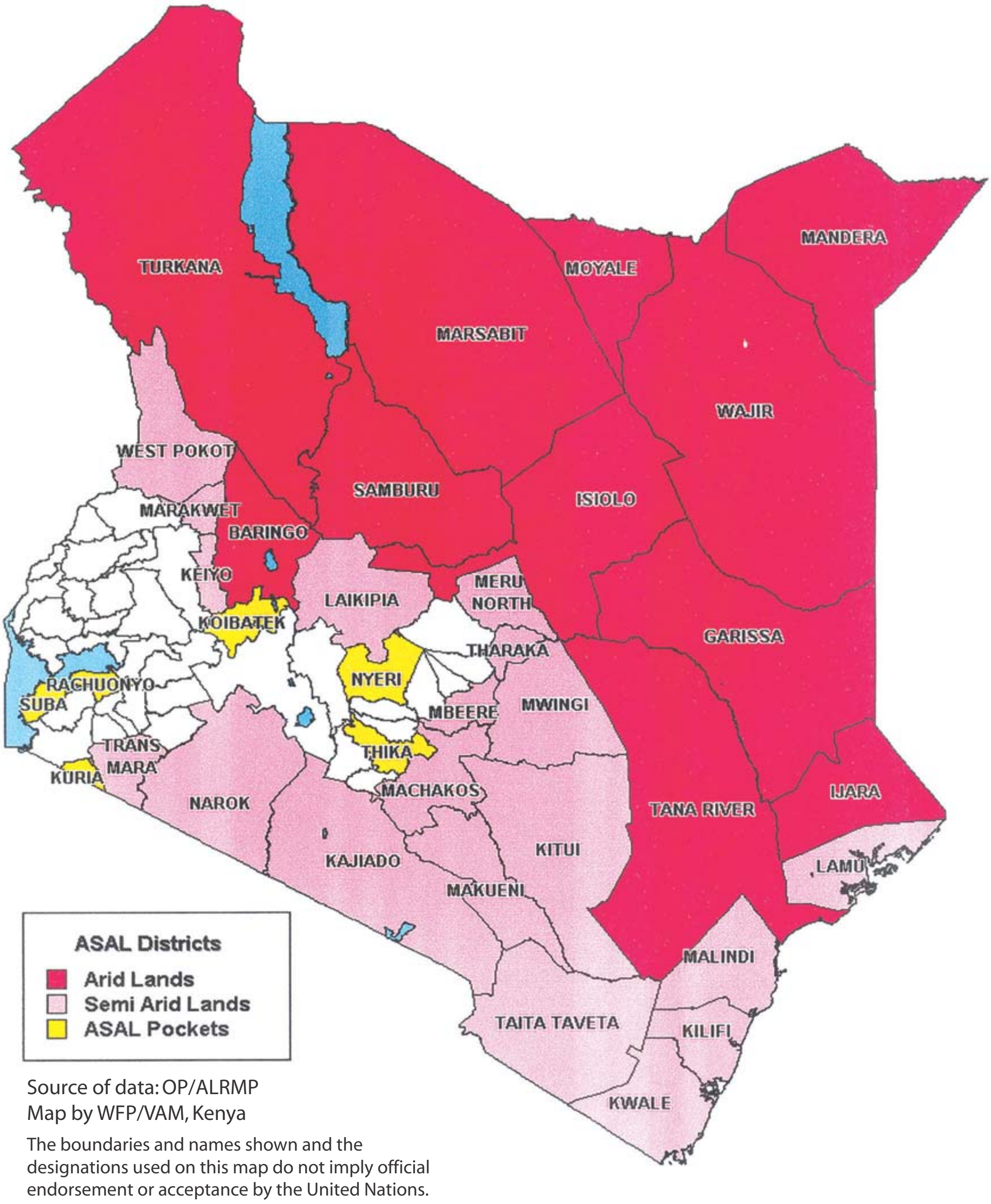
INTRODUCTION

Water Availability in Drylands

The Africa Water Vision for 2025 visualizes "*An Africa where there is an equitable and sustainable use and management of water resources for poverty alleviation, socioeconomic development, regional cooperation and the environment*" (UN Water/Africa 2003). It has nine components, two of which envision that "(i) there will be sustainable access to safe and adequate water supply and sanitation to meet basic needs of all and (ii) there will be effective and sustainable strategies for addressing natural and man-made problems affecting water resources, including climate variability." Meanwhile, research on water scarcity and its relationship to food security (Seckler et al. 1998) has projected Africa to be physically or economically water scarce by 2025. As countries struggle to implement actions that will fulfill the vision, perhaps the most daunting task befalls regions in Africa that are drylands, sometimes referred to as ASALs (arid and semi-arid lands) and they also happen to be the most drought-prone. ASALs cover about 40 percent of the earth's surface, supporting the livelihoods of over one billion people, among them are some of the world's poorest and most marginalized people (UNDP 2003). In Africa, one-third of the people live in drought-prone areas (ECA 2000).

In Kenya, the ASALs occupy over 80 percent of the land area (figure 1) accommodating 12 million (36%) of the population (Republic of Kenya 2001). But these are populations having the highest poverty levels, averaging at 65 percent, with livelihoods that are constrained by very poor access to basic social services (Government of Kenya 2003). Generally, ASALs in Kenya are characterized by high potential evapotranspiration, exceeding twice the annual rainfall, and in certain areas as much as ten times the annual rainfall (Republic of Kenya 1992). The annual rainfall is low, ranging from 150-450 mm and it rarely achieves the 60 percent probability of occurrence (Republic of Kenya 1993). Rainfall is also highly variable in space and time, and often occurs as high intensity storms. As a result, considerable surface runoff is generated, which is exacerbated by sparse vegetation cover. Water availability and accessibility is a constraint to production and is also highly variable spatially and temporally. Thus ASALs are more suited to livestock grazing systems, accommodating mostly pastoralists and agro pastoralists, who own 50 percent of the national cattle and a small ruminant herd, and 100 percent of the camel population (APD 2000). One recurring problem in the ASALs is droughts and flush floods. A drought is defined as the failure of three consecutive rainy seasons. In the past, a major drought was expected once every 10 years, but over the past three decades major droughts have recurred after every 5-7 years (CETRAD 2003). This means that ASAL livelihood systems do not adequately recover to withstand the next drought. As a result, any small shock such as a prolonged dry spell has a much bigger impact on people's livelihood strategies than in the past. This situation is aggravated by insecurity, rising poverty and declining asset levels (natural, human, social, financial and physical assets). Furthermore, the ASALs are fragile eco-systems that require protection from environmental degradation and desertification. Access to drinking water for communities and livestock are major livelihood constraints in the ASALs (Republic of Kenya 1992; 1994). Isiolo District exemplifies these issues.

Figure 1. Extent of arid and semi-arid lands (ASALs) in Kenya.

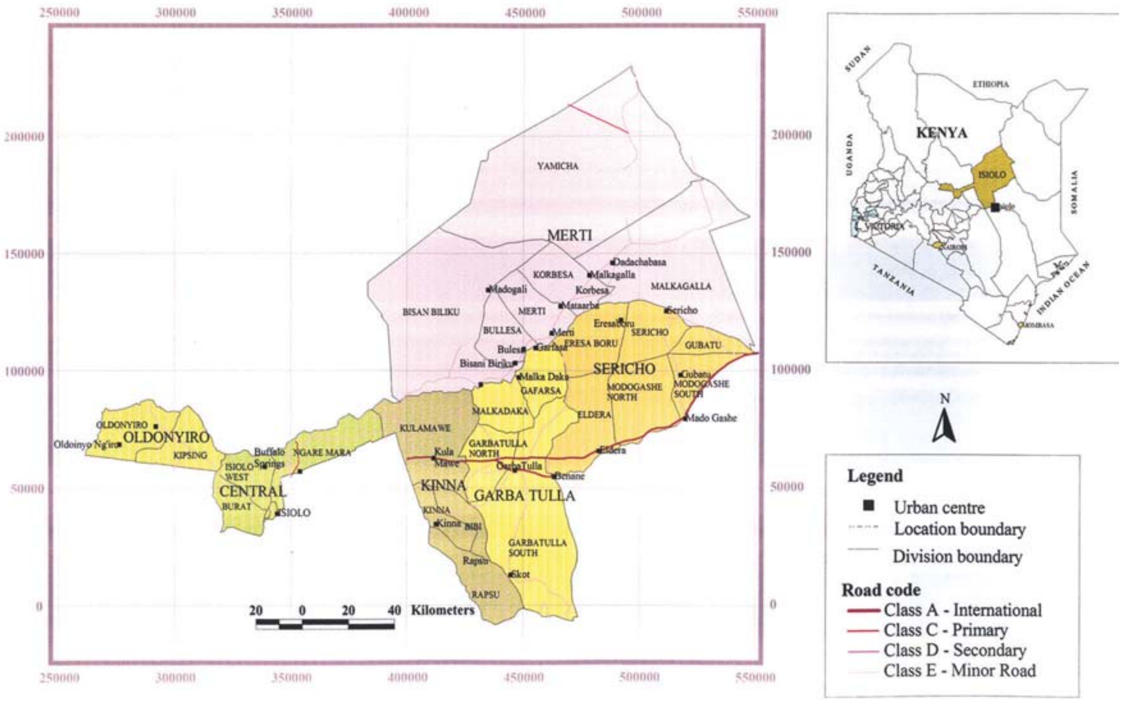


Source: Adapted from – Arid Lands Resource Management Project (ALRMP 1993), Office of the President, Nairobi

Background on Isiolo District

Isiolo District is located in the Eastern Province of Kenya, covering a total area of 25,605 km^2. It lies between longitudes 36^o 50' and 39^o 30'E and latitudes 0^o 05'S and 2^o N (figure 2). The district is characterized by flat low-lying plains, especially in the lower Ewaso Ng'iro basin, gently undulating landscapes, and in some hills and minor scarps. Altitudes range between 180 to 900 m above sea level.

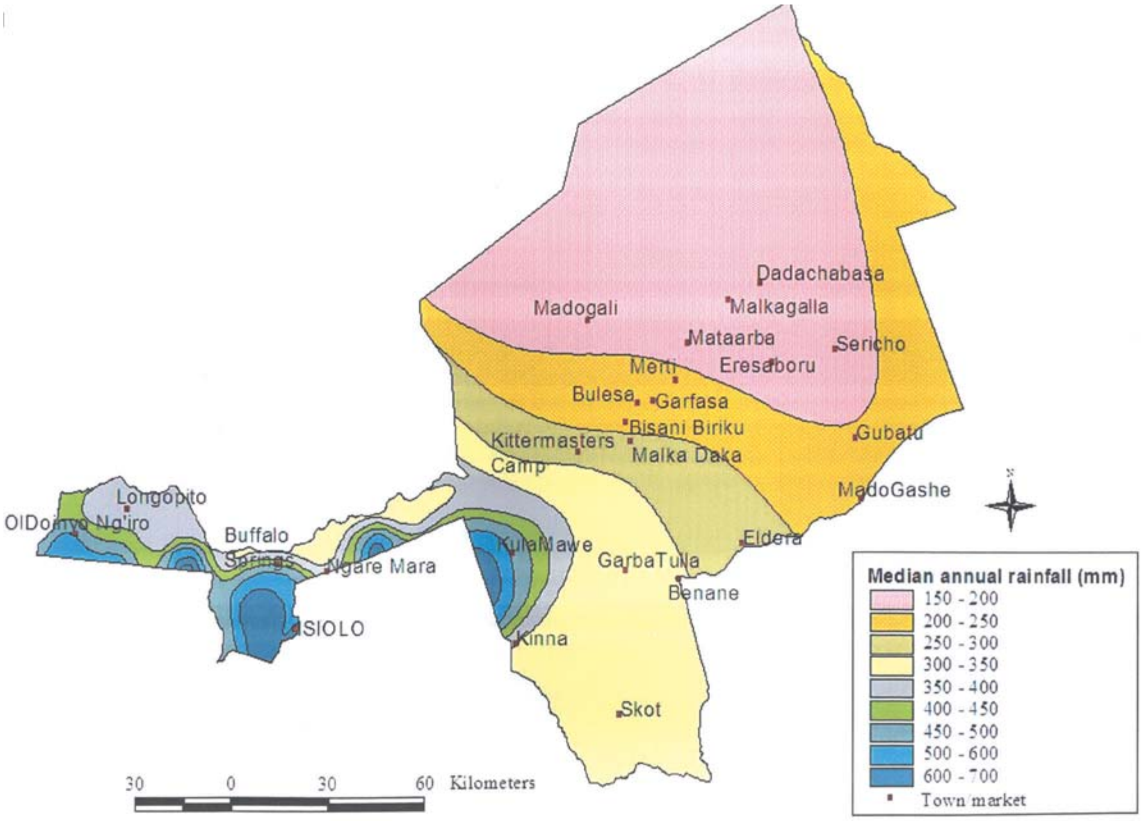
Figure 2. Isiolo District: Geographic location and administrative units.



Source: Adapted from – Department of Resource Surveys and Remote Sensing (DRSRS 1993); Ministry of Planning and National Development, Nairobi

The climate falls into three agro-climatic zones (Herlocker et al. 1993; Sombroek et al. 1982), semi-arid (occupying 5% of the area), arid (30%) and very arid (65%). The climate in the towns of Isiolo and Kinna is semi-arid and the median annual rainfall is in the range of 400-600 mm. The arid region stretches from Ol Donyiro region to Archers Post and Garbatulla areas, where the annual rainfall ranges from 300-350 mm. The very arid zones cover Merti and Sericho divisions, where the annual rainfall is between 150-250 mm (figure 3). Isiolo suffers high rainfall intensities with poor temporal and spatial distribution, resulting in short-lived excessive flooding. Under these conditions, rain-fed agriculture is unsustainable (Jaetzold and Schmidt 1983). Furthermore, evaporation rates are very high (table 1). For instance, in the Modogashe District evaporation exceeds ten times the annual rainfall, indicating yet another constraint to crop production and water storage, especially in surface reservoirs. The district is hot throughout the year with mean annual temperatures ranging from 24°C and 30°C (Herlocker et al. 1993).

Figure 3. Rainfall distribution in Isiolo District.



Source: Republic of Kenya 1993. Range Management Handbook of Kenya Vol. II, 5

Land Use/Cover

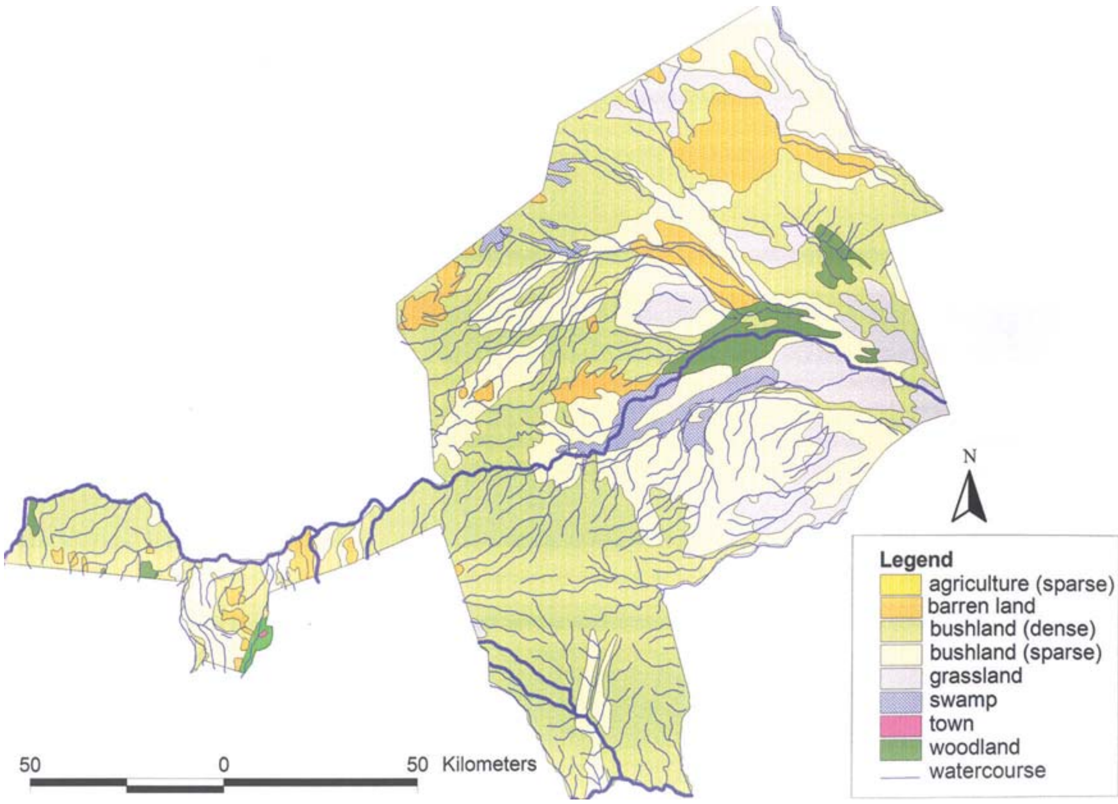
Since all the land in Isiolo District is classified as "low potential," most of the land is administered by the Isiolo County Council as "Trust land" for the Government while grazing lands are communally owned. Large areas of the district are occupied by bushlands, grasslands and shrublands (figure 4), comprising various combinations of dryland vegetation such as *Acacia reficiens, Acacia tortillis, Cammiphora spp, Duospherma eremophilum* and grasses which include *Aristida spp, Leptothrium senegalese, Sporobolus spp, Lintonia nutans* and forbs (MoWD 1991; Herlocker et al. 1993). Due to the unreliable and inadequate rainfall, crop cultivation is limited to small areas around Central Division and Kinna. With the exception of game reserves like Shaba, Buffalo and private game ranches, where ecotourism is an important economic activity, the rest of the district is taken up by communally-owned pastoral grazing lands.

Table 1. Annual rainfall reliability and evaporation in Isiolo District.

Station name	Record period (years)	Annual average rainfall (mm)	50% Reliability (mm)	60% Reliability (mm)	90% Reliability (mm)	Annual evaporation (mm)
Isiolo Town	54	623	583	538	439	2,709
Archers Post	43	350	317	274	170	3,125
Garbatulla	36	364	284	252	154	3,061
Modogashe	29	252	206	159	80	3,311
Habaswein	25	257	205	169	67	
Samburu Lodge	23	424				
Kinna Scheme	15	452				
Isiolo L.M.D.	27	619				

Source: Ministry of Water Development. 1991. Isiolo Water Resources Assessment Study. Main Report. Water Resources Assessment Section, Ministry of Water Development, Nairobi

Figure 4. Land use/land cover in Isiolo District.



Source: Republic of Kenya 1993. Range Management Handbook of Kenya Vol. II, 5

Human and Livestock Populations

Available data (CBS 1999) show that the total population of Isiolo District is 100,861 persons (table 2) living in 22,583 households, averaging at a population density of 4 persons per km^2. However, about half (52,000) of the total population lives in Central Division, of which 23,149 live in and around Isiolo Town. Records from the District Livestock Office (2002) showed that there are about 146,000 head of cattle, 183,200 sheep, 205,600 goats, 30,000 camels and 15,500 donkeys in the district. Pastoralism employs directly and indirectly about 56 percent of the adult labor force (Chabari 1993). Over the years, livestock numbers have increased, owing mostly to immigration by pastoralists from the drier north, due to the presence of the Ewaso Ng'iro River in Isiolo, which is the only permanent river in the region. The population has also grown rapidly, both in numbers and in the diversity of ethnic groups that share the resources. Isiolo Town itself is a frontier trading centre linking the inhospitable north to the rest of Kenya and consequently to livestock markets. As a result, the grazing and water resources in Isiolo have been stressed. This situation triggered a series of conflicts. The district suffered under the "Shifta" wars of the late 1960s (Thurow and Herlocker 1993), and in recent years, there have been many conflicts, sometimes escalating to full-fledged armed battles between the various ethnic groups. Most recent conflicts took place in 2001, with fighting between the Boran, Somali, Turkana and Meru communities over grazing lands near Isiolo Town, and access to water.

Table 2. Human and Livestock populations in Isiolo.

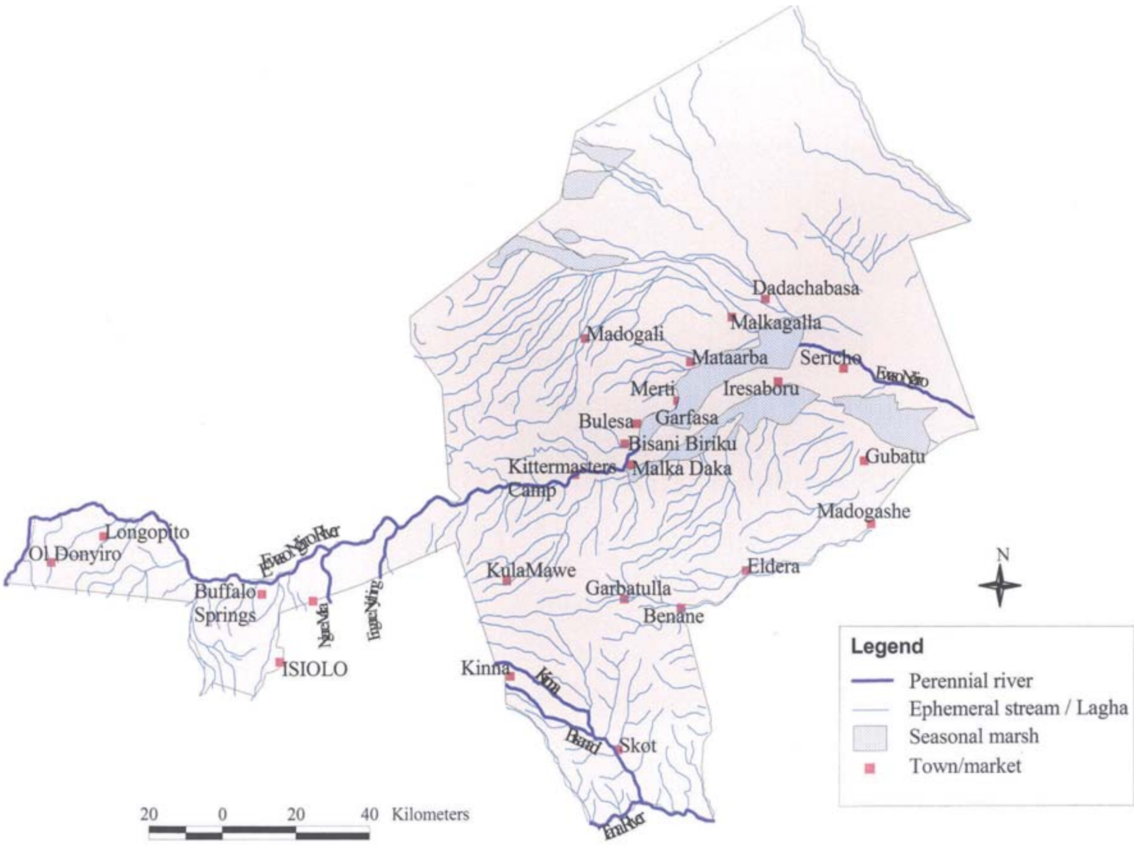
	Population					
Division	Human	Cattle	Sheep	Goats	Camels	Donkeys
Sericho	8,998	40,498	45,800	51,400	6,000	5,425
Merti	15,771	32,080	45,800	51,400	3,000	3,875
Garba Tulla	7,010	13,000	18,320	20,556	7,500	1,550
Kinna	7,133	12,936	36,640	41,120	7,500	3,100
Central	52,280	31,850	9,160	10,280	1,500	775
Ol Donyiro	9,669	15,535	27,480	30,844	4,500	775
Isiolo (total)	100,861	145,899	183,200	205,600	30,000	15,500

Source: Population data from the Central Bureau of Statistics, 1999 Population and Housing Census; and Livestock data from records from the District Agricultural and Livestock Office, Isiolo (2002)

Drainage System

The drainage system of Isiolo District is dominated by the middle catchments of the Ewaso Ng'iro North River (figure 5). The district can be divided into four major drainage basins, the Ewaso Ng'iro, which occupies 78 percent of the area, Tana River basin (10%) to the south, Galana Gof (7%) and Lagh Bogal (5%), respectively, (Bake 1993). The Ewaso Ng'iro is an allochton river, i.e., a river for which the discharge for most parts does not depend on the climate of the area. This is because the main Ewaso Ng'iro originates from the wetter Nyandarua Mountains over 200 km in the west, while most of the flow is from tributaries from Mt. Kenya. Analysis of the rainfall and stream flow data within the Ewaso Ng'iro Basin have shown that in the lower reaches within Isiolo, dry season flows are declining with corresponding decline in rainfall. This has been attributed to the high levels of irrigation abstraction upstream, which can reach 60 percent of the river flow during the dry seasons (Gichuki et al. 1998). There are few gauging stations within Isiolo, but records at Archers Post have shown a mean flow of 20.29 $m^3 s^{-1}$ with the minimum mean monthly flow being 5.2 $m^3 s^{-1}$ and the maximum mean monthly flow at 88.1 $m^3 s^{-1}$ (MoWD 1991), indicating that river flows highly fluctuate between the seasons. Beyond Archers Post, the river is ungaged and perennial up to Bulesa, from where it becomes ephemeral, with less and less water from tributaries. East of Malka Bulfayo, the river enters a wide flood plain where it loses most of its flow, and evaporation is high. The losses in this region have been estimated to be 1,000 $m^3 day^{-1} km^{-2}$ (Lester 1985). After Malka Bulfayo, the river often changes course and meanders into ox-bow lakes. East of Merti, the river follows a more northward course, but during the rainy season, as a result of high evaporation losses, the water only reaches the Lorain Swamp at Habaswein (Bake 1993).

Figure 5. Drainage system of Isiolo District.



Source: Adapted from – Department of Resource Surveys and Remote Sensing (DRSRS 1993); Ministry of Planning and National Development, Nairobi

Resource Vulnerability and the Need for GIS Database

Isiolo District to a large extent falls within the Ewaso Ng'iro Basin, which is already facing serious physical water scarcity with upstream-downstream water conflicts (Gichuki et al. 1998). The district lacks basic infrastructure and is underdeveloped in comparison to other parts of Kenya (Republic of Kenya 1997). There is no bitumen covered road in the entire district. The few rural roads are in poor condition and, therefore, impassable during the rainy season, hampering accessibility to livestock markets such as Nairobi and Mombasa. There is no piped water for households in the rural areas, while electricity, reliable telecommunication, schools, hospitals and other amenities are few and in poor condition. In general, the district is disadvantaged in natural and development aspects and falls within areas classified as "hardship area."

In Isiolo, human, floral and faunal survival is hampered by numerous natural and socioeconomic constraints, including low and erratic rainfall, high temperatures, high potential evapotranspiration and prolonged droughts (Thurow and Herlocker 1993). In particular, the 1997-1998 El Nino deluge in Kenya destroyed many infrastructures while the subsequent La Nina drought between 1999 and 2000 was even worse, as half the livestock in many vulnerable districts in the country perished (APD 2000). Isiolo District was hard hit by both of these phenomena as water conservation and conveyance structures were destroyed by the El Nino rains, while during the La Nina pastoralists from drier districts moved into Isiolo exacerbating an already overstretched ecosystem, and many head of cattle were lost (District Water Engineer, personal communication). There was an urgent need to supply water to thousands of people and livestock. Many relief organizations pledged support, but the actual numbers affected were unknown. The situation was made particularly precarious by the poor infrastructure and lack of information with which to plan coordinated emergency recovery and mitigation interventions. It was difficult to know where water facilities were, their condition and other basic information to facilitate a quick response to an emergency situation. Data available at the District Water Office was in files and inaccessible to relief organizations quickly and in simplified formats. The Ministry of Water Resources Development and NGOs active in the district felt the need to create a centralized spatially referenced water information database to enable planning of faster responses and interventions in the future. In addition, such an information base could be used for inventory, planning, assessment and management of the water resources. This meant developing a database which would help to quickly identify community and livestock water availability and access. It was agreed to develop a Geographic Information Systems (GIS) database.

DEVELOPING THE GIS DATABASE

Background to the Water Resources Information for Isiolo District

The earliest documented reports on the waters of Isiolo District were made around 1893. Then, European explorers passing through the area recorded the presence of the Ewaso Ng'iro River and its mysterious disappearance into the Lorian swamp (Williams 1966). In the 1940s, the first of a series of geological surveys were carried out for groundwater exploration, and extensive hydrological measurements made within the Ewaso Ng'iro basin (Tetley 1940; Williams 1966). However, very few water sources were constructed. In the late 1950s, geological surveys were carried out in various parts of Isiolo by several engineering firms. The Hydraulics Branch of the Ministry of Works (MoW 1962) conducted a comprehensive study of the water resources of the Ewaso Ng'iro basin. There is little record of much development in the 1970s, but in 1982, the Ministry of Agriculture conducted a study of "The Ewaso Ng'iro Irrigation Cluster," which also documented the climatology and hydrology of the Ewaso Ng'iro River. Towards the end of the 1980s, the Water Resources and Planning Project (WRAP) of the Ministry of Water Development (MoWD 1991), initiated studies on water sources of Isiolo District. These included geophysical surveys and test drilling to elicit more information on the extent of fresh water aquifers, particularly in the eastern part of the district. Around the same time, the Cartographic Unit of the Range Management Division of the Ministry of Agriculture (Republic of Kenya 1993) conducted a thorough rangeland assessment of the district. More recently, in 2001, a baseline study was done by the Ewaso Ng'iro North Development Authority (ENNDA) on the Ewaso Ng'iro basin to capture information on water resources development, catchment conservation and capacity building (ENNDA

2002). Over the years, regular monitoring by the Ministries of Water and Livestock Development, respectively, have captured diverse amounts of data, which are documented in various reports. Studies that cover the entire Isiolo District have generally been few and difficult to access by different stakeholders at short notice.

Data Acquisition

In the past, spatial databases in Isiolo have been developed mainly from low resolution remotely sensed data and used for resource assessment, land cover mapping and planning (ENNDA, 2002, Republic of Kenya, 1993). However, this study utilized GIS techniques, nonspatial data from records and interviews with key stakeholders and communities to identify and map developed water sources/points in the rural areas of Isiolo District. The study was conducted between 2002 and 2003 by a multidisciplinary team comprising researchers, government officers, local communities and NGOs. Baseline data on water sources, their location, condition, quantities and quality were obtained from records at the District Water Office in Isiolo, the Ministry of Water Resources Management and Development in Nairobi, District Offices of the Ministry of Agriculture and Livestock Development, Isiolo District Development Office and the Central Bureau of Statistics. In addition, the Range Management Handbook (Herlocker et al. 1993) and the Water Resources Assessment Project (WRAP) reports (MoWD 1991) provided additional information. Baseline maps in digital formats were obtained from the Range Management Division of the Ministry of Agriculture and Livestock Development (MoA&LD) in Nairobi and the International Livestock Research Institute (Thornton et al. 2003). The thematic data from these sources included landforms/elevation, soil, rainfall, geology, surface hydrology, vegetation and the rangeland condition. In Kenya, government records are kept according to administrative units such as districts, divisions and locations (MoWRD 2002; APD 2000). Thus, the general characteristics of each water source (boreholes, shallow wells, springs, water pans/ponds, rivers/streams, subsurface dams, infiltration galleries and emergency "water-tankering") were recorded to show; the code number, name/locality, geographic position, type of water source, operational status, management, water quality (salinity), reliability/water availability across the seasons, method of abstraction, water yield, date of construction and other available details.

These data were ground truthed with GPS (Geographic Positioning System) mapping of developed water sources/points and, in addition, local people were interviewed using semi-structured questionnaires in Kinna Division. This helped provide estimates of the number of people and/or animals accessing a specific water source in respective seasons, the condition of the water facility, prospects and constraints faced as well as management. Although some of the water sources managed by committees kept records (especially boreholes for which the pastoralists paid token fees for the water drank by their animals), it was difficult to find these records since they were considered confidential by the chairmen and treasurers of the relevant committees.

Assessing Access to Water Sources

This study utilized ArcView GIS for spatial data analyses (Ormsby et al. 2001). The GPS mapping obtained point data which was matched with attribute data from records and reports (MoWRD 2002). GIS thematic maps were developed to show major bio-physical characteristics of the district such as rainfall distribution, land use-cover, drainage systems, hydrogeology and grazing potential. In addition, spatial data on water resources was developed showing location of water sources, their types (springs, pans, dams, boreholes, wells and waterholes), their operational status, management systems, reliability, salinity status of boreholes and wells, geology as well as derived maps of access to water. A total of 43 thematic maps were developed in the study, out of which 12 of the most representative ones are presented in this paper. The rest can be obtained from the District Water Office-Isiolo, Meru Dryland Farming Project offices in Meru and Cordaid in Nairobi, Kenya.

Access to water was determined using GIS buffering operations. Buffering is a GIS tool that creates a circle of specified radius for point data such as a well, or parallel lines of specified distance from linear data such as a river or a road (Ormsby et al. 2001). Thus, a buffer defines a zone of influence from a point, area or linear items (ESRI 1996; Davies 1996). In this study, point buffers were used because the focus was developed water sources. Linear buffers were also created for rivers having all-year flows. In this connection buffers measuring 5, 10, 15 and 30 km, respectively, were created around each water source. These depict access to water within 5, 10, 15 and 30 km. Based on information from the local people, the following assumptions for drought conditions were made: (i) that humans can travel a maximum of 5 km to fetch water in a day (being 10 km with the return journey); (ii) 10 km is the maximum distance for cattle to access a water source. (However, Pratt and Gwynne, (1977) recommended 4 km for cattle without stress); (iii) the maximum distance for small livestock is 15 km; and (iv) 30 km is the maximum distance for livestock at stress levels. It is assumed that water sources exceeding 5 km radius are beyond realistic reach for domestic water supplies, and hence are only available for livestock. Field observations indicate that livestock subjected to stress levels without water and trekking for 30 km (60 km return) is something the pastoralists would like to avoid, especially for nursing animals. Therefore, they indicated that maximum distance to water should not exceed 15 km from any village. Moreover, livestock may not graze around a water point to avoid infringing on grazing rights of the clan that owns the surrounding land, and this is sometimes another cause of conflicts. Since land is communally owned by clans, there is a traditional understanding that access to water may not be denied to anyone or any animal, but access to grazing may not necessarily be allowed across clan lines.

WATER AVAILABILITY AND ACCESS FOR COMMUNITIES AND LIVESTOCK

Human and Livestock Water Demand

The per capita domestic water consumption in the rural areas of Isiolo is estimated as 20 liters per day (MoWRD 2002). This includes water for cooking, bathing and washing. One must also note that facilities like showers and flushing toilets do not exist in these areas. Unless the quality is too poor (usually high salinity), nearly all the water sources used by livestock are also used by humans, even when visibly turbid and polluted as in pans. Livestock water demand was estimated based on the drinking requirements of one Tropical Livestock Unit (TLU). According to the Range Management Handbook (Republic of Kenya 1994), one TLU is equivalent to 250 kg live weight. Thus, an average Boran cow is about 0.9 to 1.0 TLU, while one cow is equivalent to 10 goats or sheep in terms of requirements for browse. A camel is assumed to be equivalent to 3 TLU. Under normal conditions, one cow requires about 20 liters of water per day, because nearly all the animals are zebu and have lower body weight.

The total demand for human and livestock drinking water in Isiolo District (table 3) is 6,018 m^3 per day. This corresponds to about 2.2 million m^3 per year. It excludes water demand for agriculture, pasture and commercial uses. These figures were derived by summing up human and livestock water demands, respectively. Human water demand was calculated by multiplying the per capita requirement (20 liters) with the total population, while livestock water demand was calculated by using weighted values to derive livestock population in terms of TLU, and the total TLU multiplied with daily livestock water demand (also 20 liters). Some water sources are meant only for human consumption, hence they have zero water demand for livestock. Livestock water demand in Isiolo District is affected by immigration of pastoralists in the dry season, and emigration in the wet season, but such records were not available for each water source. In most cases, the demand does not match supply, which is variable. This has also been a cause of conflicts over water and other resources, especially during the dry season, when demand outstrips supply (Gichuki 2004). It is apparent that two-thirds of the water is utilized for livestock drinking (table 3), as the communities are predominantly livestock keepers. As such, there is a need to develop sources that serve livestock.

Table 3. Human and livestock water demand in Isiolo District.

	Water Demand (m^3/day)						
Division	Human	Cattle	Sheep	Goats	Camels	Donkeys	Total demand
Sericho	180	810	92	103	30	54	1,269
Merti	315	642	92	103	15	39	1,205
Garba Tulla	140	260	37	41	38	16	531
Kinna	143	259	73	82	38	31	625
Central	1,046	637	18	21	8	8	1,737
Ol Donyiro	193	311	55	62	23	8	651
Isiolo (total)	2,017	2,918	366	411	150	155	6,018

Source: District Agricultural and Livestock Development Office, Isiolo

Water Availability

Natural Surface Water Sources

Rivers and Streams: Rivers and streams form a major source of water for domestic use and livestock watering. The Ewaso Ng'iro River is the most important source of water in Isiolo District, especially for livestock watering, with animals from drier districts of the north immigrating to its banks during dry spells. The other permanent rivers, Ngare Mara, Engare Nything, Bisanadi and Kinna run mostly through Meru North District, and only traverse a short distance into Isiolo, thus have less impact on water availability in the district (Republic of Kenya 1997). However, their flows are very low, averaging 0.10 to 0.33 $m^3 s^{-1}$ (MoWD 1991). In addition, these tributaries traverse very short distances within the district. The rest of the district is criss-crossed by many ephemeral valleys and gullies (locally called *lagha*). These are ungaged and handle large volume of flush floods during the rains, but remain dry for most of the year. However, the potential for water harvesting in these valleys is enormous. Generally, river/stream water is not a sustainable source of water in the district.

Springs: This study mapped 12 springs in Isiolo District, of which 7 were operational. Most of the springs are situated within game reserves, and as such, are not accessible to local people. Older records show a total of 24 springs scattered along major rivers in Isiolo. However, 12 of these springs with negligible flows (MoWD 1991; Bake 1993) seem to have disappeared in recent years. This can be attributed to environmental degradation that has taken place due to overgrazing and poor land management. However, in a few cases, springs have been rehabilitated to improve water supplies, as was found at Kinna. Before its rehabilitation, Kinna spring was choked up with silt, exposed and seasonal with a tendency to dry out during the dry season. Rehabilitation through community action in 1996 improved the ecosystem, increasing the yield to over 36 $m^3 s^{-1}$ of relatively clean water and turned the spring perennial. It now supports a community of about 2,000 people and their livestock. Springs offer a sustainable source of clean water, especially for human consumption provided they are well protected and maintained.

Developed Surface Water Sources

Data obtained in this study showed that there are 123 developed water sources in Isiolo District (table 4). Furthermore, it was found that:(i) over 58 percent of the water sources are boreholes, (ii) 17 percent are shallow wells (not counting the numerous water-holes that are dug on stream beds during the wet season), (iii) 72 (59%) of the total number of water sources are operational during the wet season, but only 44 (36%) are operational in the dry season (figure 6); (iv) Merti, Garbatulla and Sericho Divisions are poorly served with water sources, particularly during the dry season; (v) emergency water tankering is practiced at Duse, Modogashe and Dadachabasa; and (vi) water harvesting is limited to one subsurface dam with an infiltration gallery and five operational pans, out of which only one is operational during the dry season. Water quality is a big constraint because only 52 (42%) of the sources have fresh water (non-saline) of which 23 (32%) are boreholes, further limiting availability of palatable water, especially for human consumption.

Water supply and its availability in Isiolo District are dependent on the seasons, with big variations between wet and dry seasons. Severe shortages are usually reported when there is a drought, which is a common occurrence in the district. There is no piped water in the rural areas, meaning few households have potable water at home. In general, water supply in the district can be divided into four majors groups: (i) direct use of natural water sources such as rivers, streams and springs; (ii) developed surface water sources, such as earth dams, sand/subsurface dams, tanks and pans, (iii) developed groundwater such as wells, waterholes and boreholes; and (iv) emergency water tankering. The distribution of these water sources and the major types are shown in figures 6 and 7, respectively.

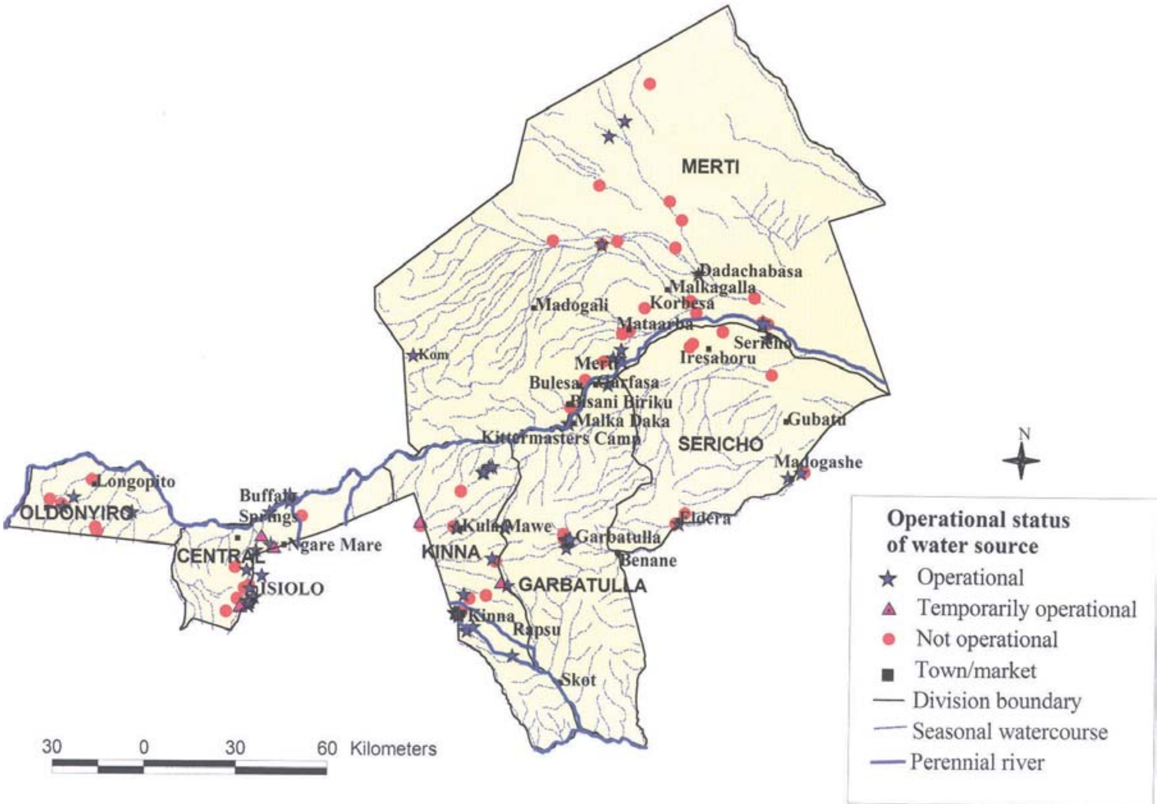
Pans and Ponds: Where the site conditions are suitable, floodwater harvesting for communities in the ASALs can be achieved by excavating shallow pans or ponds. The main difference is that ponds have some groundwater contribution while pans rely solely on surface runoff. In Isiolo, pans are more commonly used and range in size from about 10,000 to 50,000 m^3 (Bake 1993). This study identified 12 water pans, of which only one was operational throughout the year. Of the rest, 5 were operational during the wet season, while 6 were choked up with silt. However, Langat and Mwangata (1994) reported the presence of 26 pans in Modogashe West, 9 in Garbatulla and 9 in Sericho, a much larger number than those available now. The impact of the El Nino rains has been blamed for the poor status of pans in Isiolo District, as many of them were choked up with silt or breached.

Table 4. Summary of assessed water sources.

Water source type	Total number	Operational wet season	Operational dry season	Fresh water	Community Management
Boreholes	71	36	11	23	17
Springs	12	5	7	5	6
Shallow wells	21	19	19	15	15
Pans	12	5	1	2	2
Dams	1	1	1	1	1
Subsurface dams	5	5	5	5	1
Infiltration galleries	1	1		1	
Emergency water tinkering	3*			3*	
Total for Isiolo	123	72	44	52	42

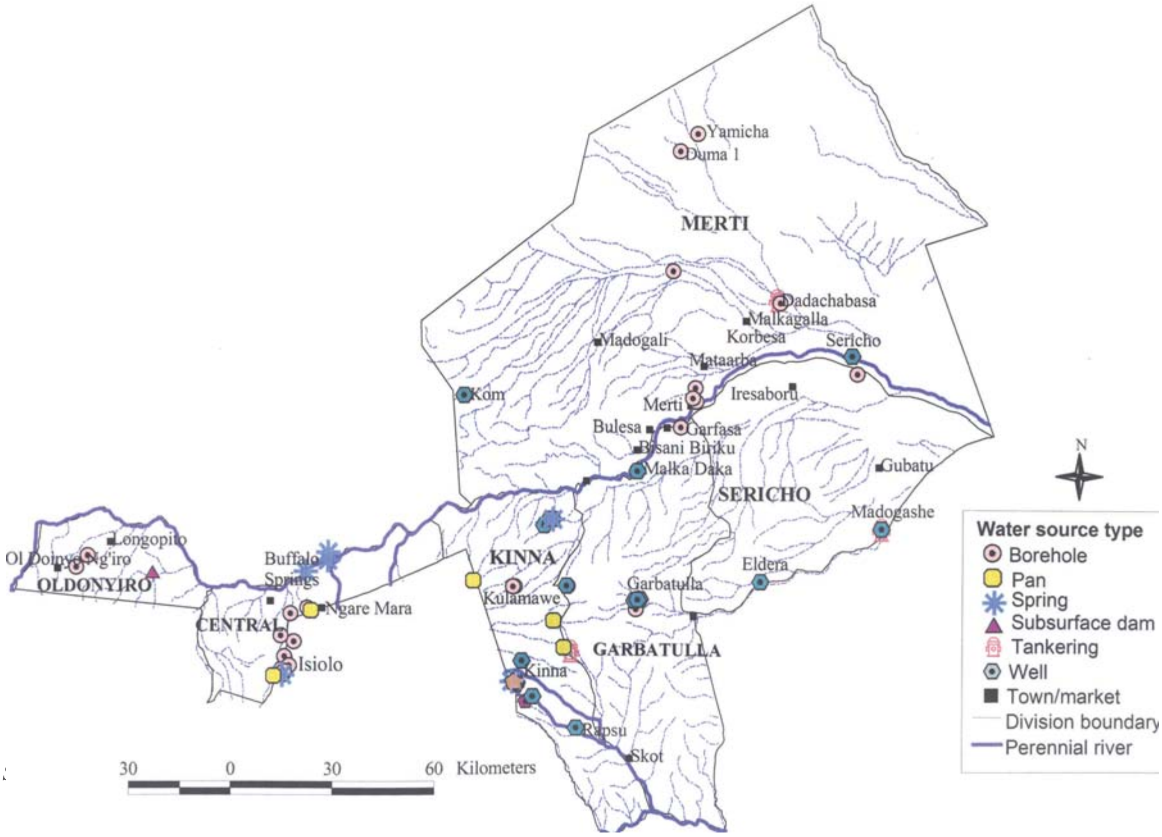
Source: MoWRD, 2002 records and field data
*Emergency water tankering not included in the summation

Figure 6. Spatial distribution of all water sources in Isiolo District.



Source: Adapted from – Department of Resource Surveys and Remote Sensing (DRSRS 1993); Ministry of Planning and National Development, Nairobi; MoWRD, 2002 records and field data

Figure 7. Types and distribution of operational water sources in Isiolo District.



Source: Adapted from – Department of Resource Surveys and Remote Sensing (DRSRS 1993); Ministry of Planning and National Development, Nairobi; MoWRD, 2002 records and field data

The WRAP project (MoWD 1991), identified rainwater harvesting and storage in dams and pans as a feasible solution, especially for the supply of water for livestock in Isiolo District. .However, their development has not been studied in detail to permit planning of interventions. The need for watering livestock is as important as domestic water, hence water harvesting in Isiolo must take into account both human and livestock water requirements. Hence, there is a requirement of larger structures such as dams, pans and ponds in the district. However, this is an expensive undertaking by local standards. For instance, the excavation cost of a small earth dam in neighboring Laikipia District (Mati 2002) was found to be about \$0.004 per liter or \$0.1 per capita based on the assumption that water demand was 20 liters/day per person or cow. This is clearly more cost-effective than borehole excavation. The cost of excavation of small earth pans and ponds is much lower than that of construction of dams as they (pans/ponds) utilize local knowledge in site selection, community labor through such programs such as food for work, thereby reducing the costs even further (Natea 2002). The main problems with earth dams and pans are siltation, contamination and high evaporation losses. In some instances, seepage can be a problem, while ownership and community management has been a recurrent constraint. Due to the relatively flat land terrain and the high erodibility of the soils, off-stream dugout pans on well-selected sites offer opportunities to supply water up to the early part of the dry season, thus reducing the time of livestock water-stress by a few months in most parts of the district (Mati 2002). Also, sedimentation can be reduced in off-stream storages if effective silt trap systems are provided.

Sand/Subsurface Dams and Infiltration Galleries: Like many ASAL regions of Africa, Isiolo District is criss-crossed by several sand rivers, whose potential for floodwater harvesting and storage has not been fully tapped. Sand rivers (locally known as *lugga, wadi and khor*) are ephemeral watercourses, which remain dry most of the year, with the valley bottom being covered by sand (Nissen-Peterssen 2000). However, sand rivers flood during the rainy season, and the flows may last from a few hours to several weeks. This flood flow can be stored in the voids within the sand, if a barrier such as a dam embankment or sand dam is constructed across the river. There are site conditions that favor a good sand/subsurface dam, including a good valley profile as is common in Machakos and Kitui Districts (Nissen-Peterssen 1996). In Isiolo, five sand dams were found in Oldonyiro Division. However, in the flatter lower reaches of the river Ewaso Ng'iro beyond Merti, sand dams may not be feasible due to unstable geological formations and the flat terrain. In such conditions however, infiltration galleries offer better scope. Expanded utilization of sand/subsurface dams in Isiolo needs to be explored, especially since when they are well designed, they suffer little siltation, provide cleaner water and are less prone to pollution and evaporation losses. Moreover, sand/subsurface dams can be quite cost-effective. For instance, subsurface dams in Machakos District of Kenya cost the community about $ 0.2-0.3 per cubic meter of water (Nissen-Peterssen 2000), and these costs are easily recoverable in the long run given that use of the water is for economic activities, i.e., livestock watering. There are possibilities for sand/sub-surface dams to positively benefit human and livestock water provision in Isiolo, given the many sand river valleys in the district.

Groundwater Sources

Boreholes: Boreholes are the most commonly used source of water in Isiolo District, constituting 58 percent of the total number of sources mapped (table 4). A total of 71 boreholes were mapped in this study out of a possible 117 boreholes sunk in the district, which appear in records (MoWRD 2002; Bake 1993). The difference being those boreholes that were not mapped either never yielded water or closed for various reasons. Of the mapped boreholes, 39 are operational under normal climatic conditions, but only 11 are operational throughout the year. Four of these, Yamicha, Duma 1, Bonji and Urura, are classified as "range boreholes," meaning that they are kept locked under normal conditions and only opened for livestock use during severe drought periods. On average, the poor state of boreholes can be attributed to lack of community management. This study revealed that only 17 boreholes (24%) out of the total number mapped had an organized community management system. Many boreholes do not operate because of lack of a system to organize purchase of fuel for pumping, or make repairs when necessary. In addition, only 23 (32%) of the boreholes have fresh water (low salinity).

Available data shows that borehole depths range from 50-100 m, with the deepest being at 250 m. Water yields range from 1 to 18 liter/s, with a median yield of about 9 l/s (MoWRD 2002). However, these flows fluctuate with the seasons, leaving only 11 (15%) of the boreholes operational during the dry season. This may be due to the fact that most of the boreholes are quite shallow and, hence, subject to seasonal hydrological fluctuations, or that there is over-pumping of the aquifers. Studies in other parts of the world have shown that unstable groundwater overdraft occurs when pumping exceeds the source's rate of natural recharge (Rosegrant et al. 2000). Overdrafting leads to a lowered water table, which in turn increases the depth of pumping, thereby raising pumping costs. Additional environmental problems may also occur from groundwater overdrafting including decreased water quality, subsiding land, and saline intrusion into aquifers. In Isiolo, further investigations are necessary to identify the causes of the high fluctuations in the water yields from boreholes.

Shallow Wells: This study identified 21 semi-permanent shallow wells (<20 m deep) in the district, most of them traditional hand-scooped holes. This number is usually higher during the wet season when more water holes (temporary wells) are dug on most of the various streambeds. A total of 71 water holes were identified by the Range Management Division (Bake 1993), and the Divison indicated the presence of 15 shallow wells alongside these. Most of the wells are used for human water supplies due to their low yields (no data). Another feature is that most of the shallow wells are: (1) not capped; (2) have no pumps; (3) have low yields; and (4) exceed 6 m in depth. In traditional Boran systems, which are practiced to date, steps are made into the well and women line up to reach down and fetch the water manually, through a "hand-me-up" system using containers. This is a slow and laborious activity, and also leads to contamination of the water. Due to the slow water yield women and girls spend long hours extracting small quantities of water. Improvements in well design and management are necessary. Prospects to improve infiltration in sand rivers, e.g., through sand/subsurface dams so as to boost the storage capacity of shallow wells, should also be explored.

Geology and Salinity Levels of Boreholes and Wells

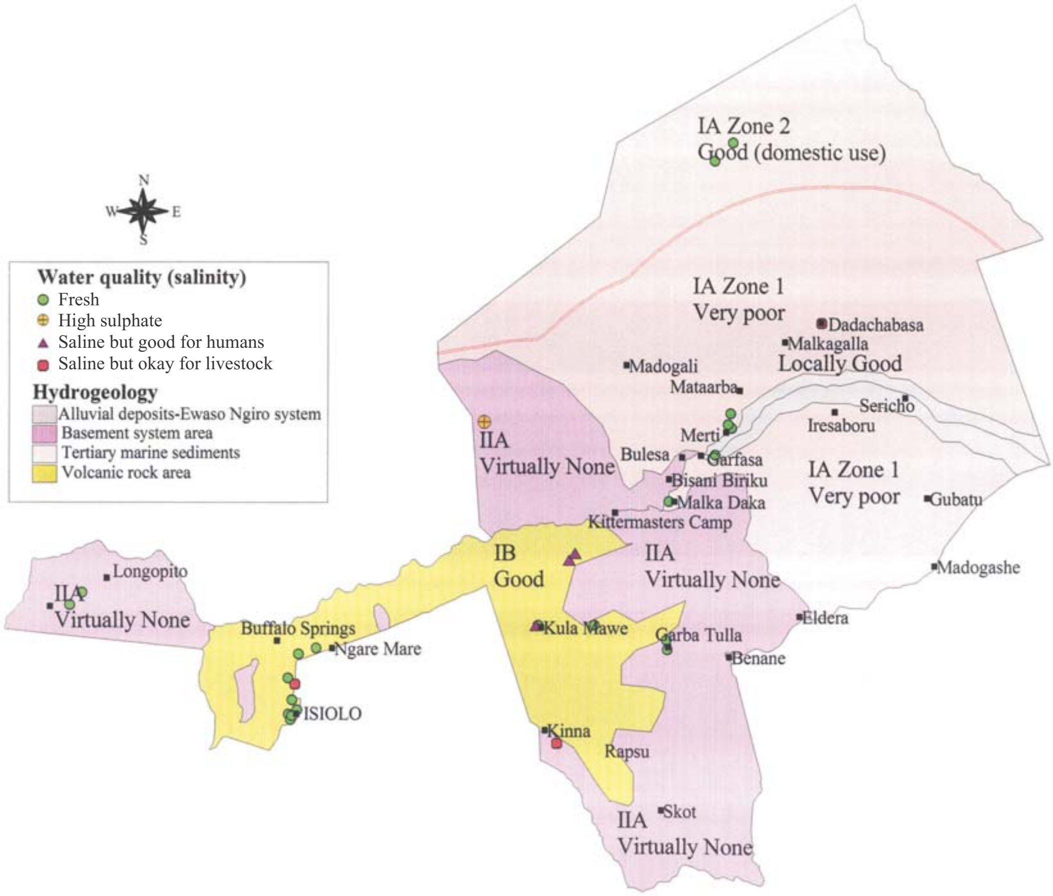
The groundwater potential of Isiolo District (figure 8), shows that about 80 percent of the district has poor to virtually no ground water potential, which includes Merti, Garbatulla, Ol Donyiro and Sericho. This could be the reason for the poor distribution of boreholes and the need to look for alternative water sources. Most of the shallow wells are found along the banks of the Ewaso Ng'iro River. The alluvial deposits along the Ewaso Ng'iro render excavation of wells in the area risky, and several wells have collapsed in the process, endangering life and property. The best formations for groundwater in Isiolo are the volcanic rock areas around Kinna and Central Divisions. There is also a problem of high sulphates in the groundwater in Merti around Kom (MoWD 1991), which further complicates groundwater use. Despite this, groundwater has not been fully exploited in the areas with suitable geologic formations.

Water quality data collected on boreholes and shallow wells in this study includes information on whether the water was: (i) fresh (could be contaminated but no salinity); (ii) saline but suitable for human consumption; (iii) saline but only suitable for livestock consumption; and (iv) too saline for any consumption (brackish). Further details on the chemical composition of the water have been provided in records (MoWRD 2002; Republic of Kenya 1993), but they do not include information on turbidity or bacteriological contaminants. In this study, only 23 boreholes (32%) had water of sufficiently low salinity that could be sanctioned for human consumption.

Emergency Water Tankering

Tankering is the provision of water to communities using water tankers from a source, usually several kilometers from the needy community, in periods of severe drought since it is quite expensive. In Isiolo District, emergency water tankering is not common, and has been reported in three places mostly during extreme drought events: (i) at Duse mines, where the mining company used to bring in water from Garbatulla to the resident miners in drought periods; (ii) Modogashe town where an NGO, Action Aid, used to bring water from Sericho to the local people; and (iii) at Dadachabasa, where Action Aid used to bring in water from Merti. Over the last 3 years, tankering has not been practiced on a large scale because of the huge costs involved. Even the District Water Office does not plan to use tankering in its future programs. Moreover, water tankering is unsustainable in the longer term.

Figure 8. Groundwater potential and water quality of boreholes and wells in Isiolo.



Source: Adapted from – Department of Resource Surveys and Remote Sensing (DRSRS 1993); Ministry of Planning and National Development, Nairobi; MoWRD, 2002 records and field data

Access to Water

Access to water (figures 9-a, -b, -c), was taken to mean the proximity to a water source by the community, depicted by the area around a water point (referred to as a buffer in the GIS) as specified by a radius of 5, 10 and 15 km. The assumption is that communities within the circle of the respective radii have access to water while those outside the circle lack access to water (within a reasonable distance). Although 30 km is the distance livestock have to walk during water scarcity periods, cattle and small stock will normally graze up to 10-15 km away from a water source (MoA&LD 2002). This is assuming that animals are not lactating, the terrain is relatively accessible (no steep slope) and water is available at the source for at least 10 hours a day. The representation of buffers in km^2 (a spatial unit) is an estimate because communities in Isiolo District measure distances traversed by livestock in time units. For instance, livestock are not necessarily watered daily. Rather, cattle are normally on a watering frequency of 2 to 3 days, small stock up to 5 days and camels up to 15 days (Republic of Kenya 1994). Two other factors are: (1) land ownership; and (2) grazing rights. The land is communally owned by clans which also control grazing rights for members. Therefore, although animals may access water across clan boundaries, they may not graze in the surrounding areas, thus requiring them to go back "home", a journey that may take 3 or more days, in which time they would be thirsty again. This vicious cycle has an adverse affect on the weight and growth of the livestock.

In terms of spatial coverage (table 5), it was found that during the dry season, about 93 percent of the district area (figure 9-a) lacks access to water to within 5 km reach, including river flow, affecting 175 (73%) villages. For human consumption, water sources beyond 5 km are considered too far for realistic access for domestic water, although in reality the local people travel much further (MoWRD 2002). In figure 9-a, it is apparent that some villages are about 75 km from the nearest water source. It is quite common in such villages to find that domestic water is fetched once or twice a week (using donkeys) and shortage of water can be very acute. When the distance from a water point exceeds 10 km, which is the maximum distance for cattle without stress, about 74 percent of the area and 52 percent of the villages fall beyond the range to a water source in the district (figure 9-b). In the case of 15 km distance, which is the maximum distance for small stock without stress, about 63 percent of the area lacks access to livestock water (figure 9-c) and this includes 92 villages (38% of total). Through such buffering operations, it is possible to show in spatial terms what it means to have access to water for pastoral communities and their livestock in the dry areas with scattered water sources.

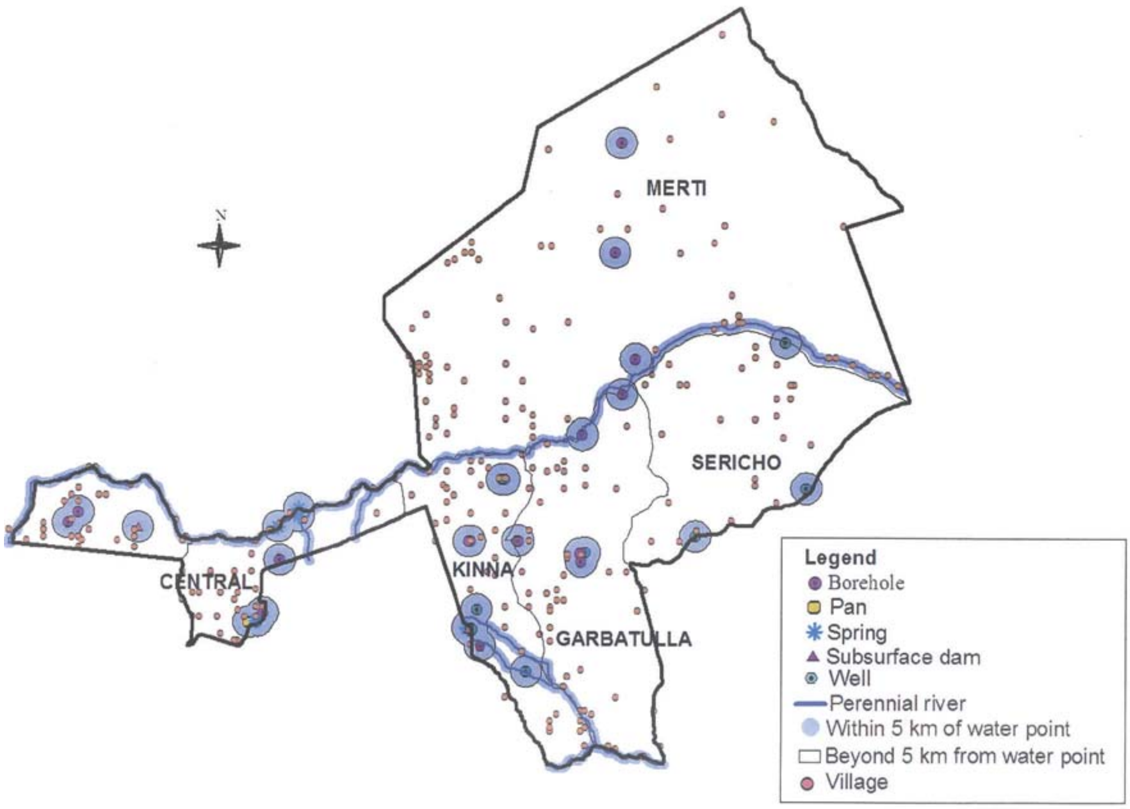
These findings demonstrate the poor status of access to water by humans and livestock in Isiolo District, at a time when the world is geared towards achieving the Millennium Development Goals (MDGs) on water. This is not surprising because as stated by Soussan and Arriens (2003), ASALs are where many of the most acute water problems are found. Water resources are scarce, overexploited and erratic in availability, while poverty is very high and both services and institutions are poorly developed. Other than physical scarcity, Isiolo also faces economic water scarcity. In general, water scarcity is a condition where demand exceeds supply. But economic water scarcity (Seckler et al. 1998; IWMI 2000) occurs when financial, human or institutional resources constrain the development of water resources and their availability. A condition of institutional scarcity exists when laws, traditions and organizations restrict access or are inadequate to distribute water to all, eaving some people water scarce. Physical or absolute scarcity exists when the demand for water outstrips the facilities to tap into resources, as in the case of Isiolo District. It can be argued that the Isiolo physical scarcity is also a function of economic scarcity, i.e., insufficient capacity to invest enough to make water available. This has serious constraints on production, especially as Isiolo has livestock-based economies.

Water harvesting has remained largely unexploited in Isiolo District (MoWRD 1991). The provision of drinking water through rainwater harvesting in ASALs has proved successful in many parts of Africa as with construction of surface tanks for roof catchments (Gould and Peterssen 1999), flood flow harvesting into underground tanks, pans and ponds (Guleid 2002; Nega and Kimeu 2002), as well as impoundment of flush floods in valleys and storage into sand and subsurface dams, earth dams and infiltration galleries (Nissen-Peterssen 2000; Mati 2003). In contrast, there are few surface tanks for roof water harvesting in Isiolo District. This could be attributed to the

Table 5. Areas and number of villages within/beyond water sources by 5, 10 and 15 km in Isiolo District, determined using GIS analysis.

Radius from water source	Area within (km^2)	Percentage of area within	Percentage of area beyond	Number of villages within	Number of villages beyond	Percentage of villages beyond
5 km	1,844	7	93	65	175	73
10 km	6,588	26	74	116	124	52
15 km	9,375	37	63	148	92	38
District total	25,605			240	391	

Figure 9-a. Dry season access to within 5 km of water sources in Isiolo District.



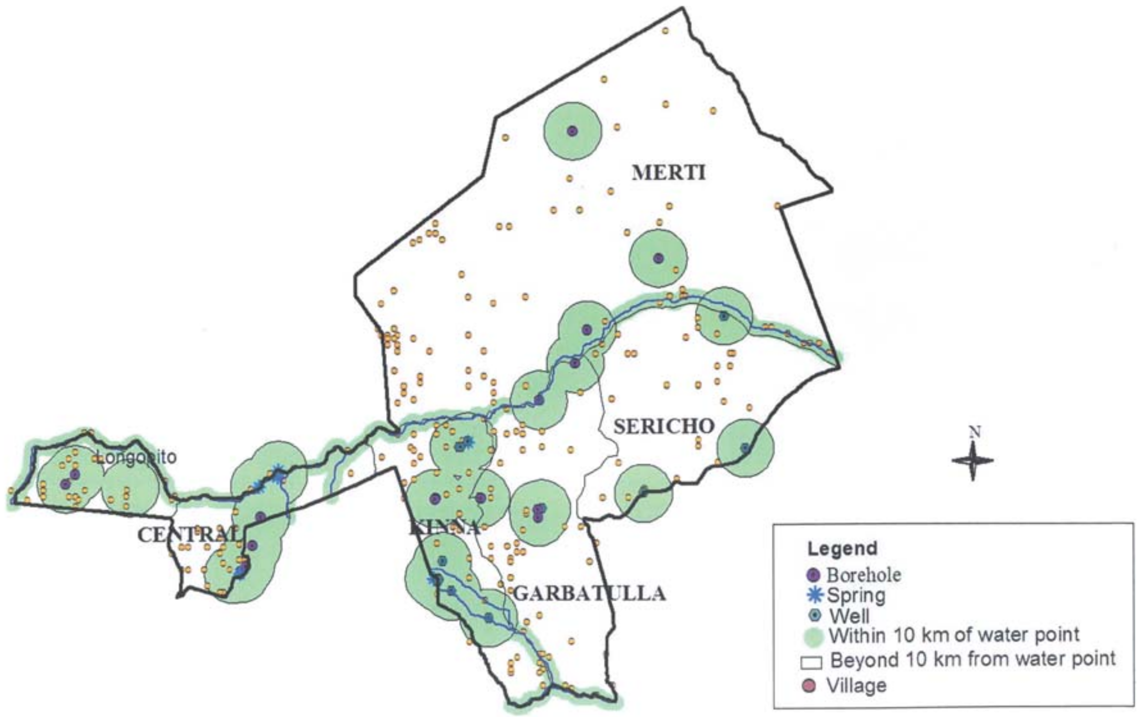
Source: Adapted from – Department of Resource Surveys and Remote Sensing (DRSRS 1993); Ministry of Planning and National Development, Nairobi; MoWRD, 2002 records and field data

nature of the traditional housing, which comprises igloo-like grass-thatched huts, and the fact that settlements among the pastoral communities are temporary. In addition, roof water harvesting entails relatively high initial investments by local standards. Using experiences from neighboring Laikipia District, Mati (2002) calculated the cost of tank construction per capita to be about $150 (equivalent to about $0.07 per liter). Only a few modern houses have been constructed having a corrugated iron roof, which can be used for water harvesting, at least to alleviate domestic water scarcity.

Interaction between Grazing and Water Availability

Livestock production is the main economic activity of communities in Isiolo District (Chabari 1993), and thus the availability of good grazing and browse material or rangelands is as important as water provision. In general, rangeland productivity is related to rangeland health and vitality, while range condition is the relation between present potential and productivity (Pratt and Gwynne 1977). The map of the range condition (figure 10) shows that about 40 percent of the district has good grazing resources in terms of biomass and species. These are the areas where the vegetation comprises *Sporobolus-Chrysopogon-Acacia recifiens*, *Dactylocterium-Leptothrium-Duospherma*, and C*ordia-Acacia tortillas-Commiphora* species, and covers parts of the northeast in Merti District and parts of the southeast in Kinna Division. On the contrary, rangelands having *Aristida-Chloris-Cordia-Cammiphora* deciduous bush annual grassland, *Aristida-Cordia-Cammiphora-Boswellia-*

Figure 9-b. Dry season access to within 10 km of water sources in Isiolo.

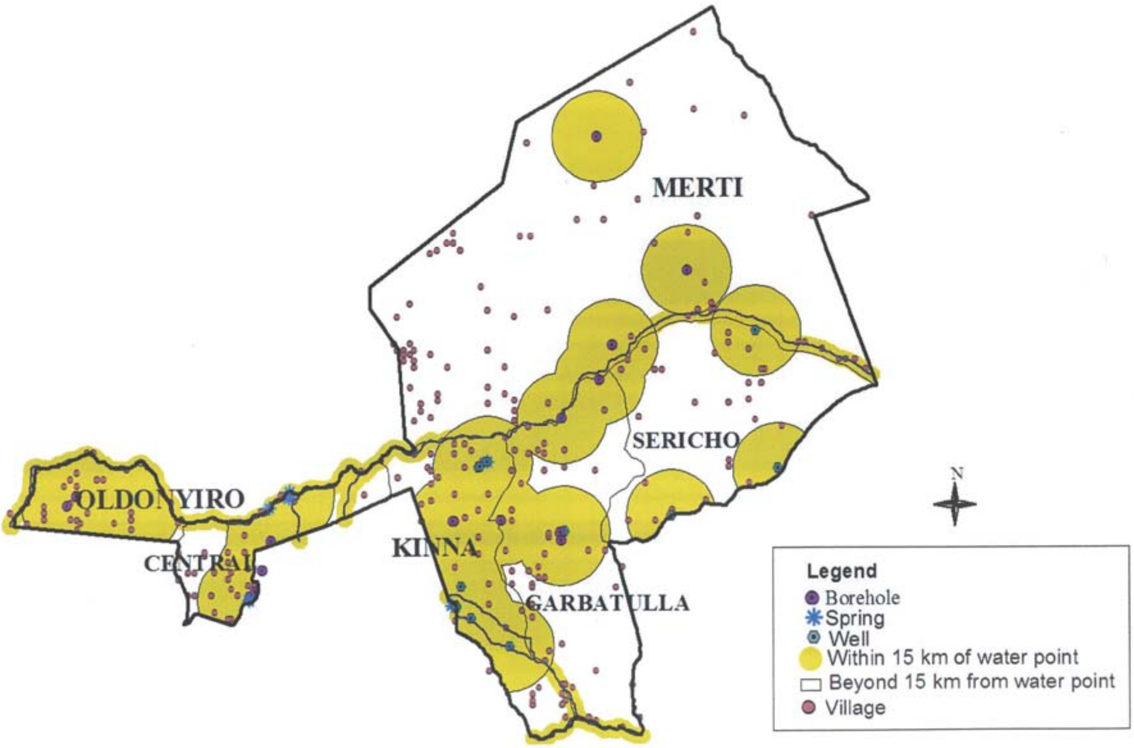


Source: Adapted from – Department of Resource Surveys and Remote Sensing (DRSRS 1993); Ministry of Planning and National Development, Nairobi; MoWRD, 2002 records and field data

Ipomea-Grewia deciduous bushland and *Acacia reficiens-Boscia*, deciduous shrubland offer poor grazing (Herlocker 1994). However, in-between the aforesaid areas there are moderate grazing resources.

The poor distribution of water sources is probably the main cause of poor distribution of livestock in the rangelands, especially during the dry season. Without a water source, it is difficult to keep livestock in an area long enough to achieve proper utilization of forage. Consequently, large numbers of animals concentrate on the few water points leading to heavy grazing pressure and trampling of soil within several kilometers of a water point. The result is retrogression of plant communities to the dominance of less palatable species. And with the dwindling of the palatable species further overgrazing takes place setting off a vicious cycle of degradation. In Isiolo District, such rangeland deterioration over the years has led to the loss of palatable species such as bunch grass (Herlocker 1994). This study found that areas with good grazing potential suffer water scarcity and those with available water have poor grazing resources. Furthermore, the type of forage available determines the seasonality of grazing resources and whether to install water supply facilities or not. For instance, if the dominant grasses are annuals, it makes no sense to put in a well for improving livestock access during the dry season. Accessibility to fodder may also be limited by landform and soil. In Isiolo, flooding of the River Ewaso Ng'iro, north of Malkadaka during the rainy season impedes livestock mobility in these areas, forcing animals to concentrate in the south (Republic of Kenya 1993).

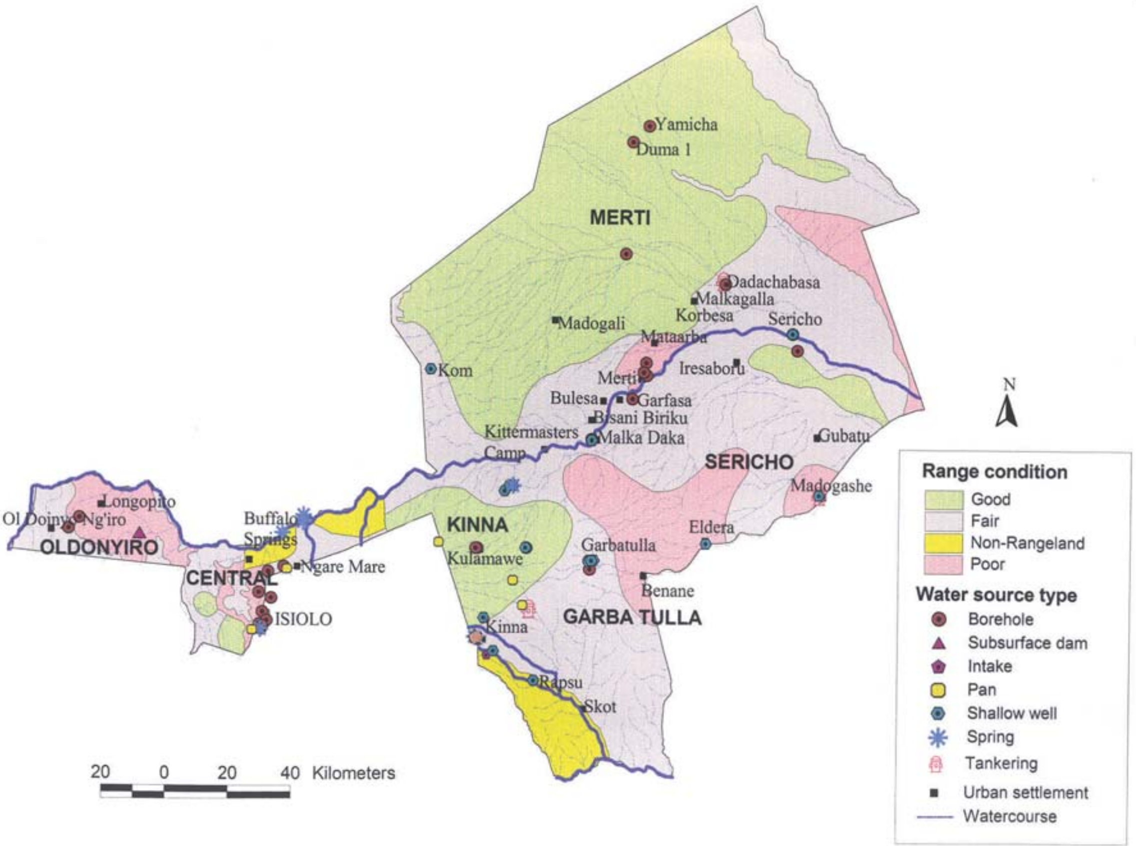
Figure 9-c. Dry season access to within 15 km of water sources in Isiolo District.



Source: Adapted from – Department of Resource Surveys and Remote Sensing (DRSRS 1993); Ministry of Planning and National Development, Nairobi; MoWRD, 2002 records and field data

It has been argued that bringing development to ASALs by increasing the number of water points for livestock may not necessarily achieve the desired results (Thurrow and Herlocker 1993). This is because traditionally, water availability in the dry season was the critical factor that limited livestock populations and pasture access. Traditional systems often had well-defined rules governing access to resources and their utilization. Disease also limited human and animal populations. The natural checks prevented intensive land use and environmental degradation, which would have caused a reduction in the overall carrying capacity. Introduction of veterinary services and the provision of water through boreholes have removed these limitations leading to human and animal population growth, but these have happened in the absence of sound management. The new factor that becomes dominant in the control of livestock populations is lack of forage. Since pastoralists like to keep large herds of livestock, overgrazing consequently causes land degradation. Therefore, in addition to water developments in the future, which are needed for areas with severe scarcity as in Merti and Sericho Divisions, there is a need to balance the new interventions with the number of livestock as well as the grazing resources. This is especially important among communities as in Isiolo where pastoralism continues to be the predominant way of life.

Figure 10. Grazing/rangeland potential and operational water sources in Isiolo.



Source: Adapted from – Department of Resource Surveys and Remote Sensing (DRSRS 1993); Ministry of Planning and National Development, Nairobi; MoWRD, 2002 records and field data

Management of Water Facilities

Management of the water facilities in Isiolo is crucial due to the communal nature of their utilization. Only 42 (34%) of the water sources have an organized system of management, mostly comprising a water committee, but a few facilities are managed by religious organizations, NGOs, individuals and companies (usually hotels in game reserves). In the case of boreholes, only 17 (23%) are managed by the community, 6 by NGOs and the rest, 46 (65%), do not have an effective management system. It was noted that operational reliability of water sources was associated with the availability of good community management structures. At a time when focus is shifting from government-managed water systems to community-based ones (MoWRD 2002), community involvement in water management in Isiolo District is still lagging behind. Of the available water committees, their main functions include ensuring order in the sharing of water from boreholes, collection of revenue for purchase of fuel, pump maintenance and generally acting as caretakers of the water facility.

Most of the water committees in Isiolo are ad hoc organizations (not registered, therefore no bank account), lacking a written code of conduct or bylaws. At the time of this study, there were no Water Users Associations (WUA), partly because this was still a novel concept in the area. WUAs possibly can contribute to poverty reduction and increase the participation of users in the decision-making process (Hussain et al., 2001). It is important to build institutions such as water committees. Traditional water management institutions are common in Africa, and exist in Isiolo District. For example, the Boran of Isiolo has a traditional method of closing certain strategic water facilities (in this case boreholes) which are only opened during severe drought conditions. Under this system, Isiolo District is served by 4 "Range boreholes," namely Yamicha, Duma 1, Boji and Urura. These boreholes are kept locked under normal climatic conditions, and only opened for livestock watering during drought periods. Unfortunately, donor and NGO interventions have tended to undermine, not build on and support these local traditions. For example, in Isiolo, most of the water sources have been provided by funded projects through the government and NGOs, where community participation was limited to the provision of manual labor and some locally available materials, and sometimes no involvement at all. The costs of spare parts are high, while fuel and all equipment must come from Nairobi over 400 km away, making it very difficult to maintain them. Alternatives to water from boreholes such as water harvesting are necessary.

Water supply and management in Isiolo District is influenced not only by bio-physical conditions but also by national policies and socioeconomic structures. In Kenya, water supply schemes in rural areas have in the past been subsidized by the government (MoWRD 2002). Recently Kenya has developed water policies to devolve water supply and management from the government to private sector and communities (Republic of Kenya 2001). The new policy is a shift from providing water as a basic human need either free or at a very low cost to the poorest communities, towards greater cost recovery for the supply of water in general. The impacts of these policies will require re-assessment in the Isiolo District, especially as the policies were developed with sedentary human settlements in mind, whereas most people in Isiolo are pastoralists.

Cost recovery is becoming a big issue in community water provision and management worldwide. But the implications of cost recovery among poor rural pastoralists as in Isiolo, having cultures that are not money-oriented need to be assessed further for it (cost recovery) to work snag-free. Generally, most countries aim at full cost recovery for bulk industrial water use, but adopt a more flexible approach (little or no cost) to cost recovery for basic water services provided to the poor people in rural areas. Since water was previously treated entirely as a social good and provided at little or no cost, the move to full cost recovery needs to be a gradual one in order to avoid negative socioeconomic impacts (Adom et al. 2001). The challenge is to find out how best to harness this capacity and maximize its use with rural communities. Introducing cost recovery measures in Isiolo District is not a new thing as the communities already have a culture of cost-sharing, especially where bore-hole water is abstracted. Poor record keeping and bad accountability on the part of the water committees has sometimes demoralized community members, which has led to the collapse of several water projects.

CONCLUSIONS AND RECOMMENDATIONS

Identifying and mapping of water sources in drought-prone areas is an important step towards developing knowledge bases that can be used for mitigation and emergency response planning. This was very important in Isiolo District, which suffers droughts every 5-7 years, and access to water is critical to the survival of communities and livestock. Hence, this study utilized data mostly obtained from records kept by the Isiolo District Water Office, and secondary data obtained from reports, especially the Water Resources Assessment Program (WRAP) and the Range Management Handbook of Kenya. The GIS baseline data obtained from the Range Management Unit was mostly of scale 1:1 million, but the study added value to these data through GPS ground truth surveys. Population data obtained from national 1999 census records was considered adequate for district level analysis, but was not very useful in matching water sources to number of users. The district records did not contain such level of detail and it was not possible to know how many people used a specific water point. This level of detail is necessary in order to capture the seasonal dynamics in water use for a specified source. The data on livestock obtained from the Ministry of Agriculture and Livestock Development were also not detailed enough to show the number of animals per water point, per day or season. The migratory pattern of the livestock vis-à-vis the water source is an important component to put in a GIS database, and should form part of future studies.

With only 36 percent of the water sources found to be operational during the dry season, the database highlights the poor condition of the water availability to humans and livestock in the district. In addition, the people walk sometimes over 50 km to get water during the dry season. The database can be used to plan the most appropriate location of new developments or rehabilitation of the most crucial ones. Moreover, the people of Isiolo District rely mostly on boreholes, which account for 58 percent of all developed water sources. Yet only 20 percent of the area has good groundwater potential. Water supply infrastructure in Isiolo has been plagued by problems such as siltation of pans, breaching of embankments, poor maintenance of pumps and lack of fuel to run boreholes and, generally, the under-performance of the facilities. As only 34 percent of the water facilities have some form of institutionalized community management, thus issues of community empowerment and mobilization to improve water governance and management are necessary. With 93 percent of the villages located beyond the benchmark 5 km of the nearest permanent water source, it was concluded that Isiolo District lacks adequate and reliable water sources within a reasonable distance for community and livestock use.

The major recommendations from this study include the need to rehabilitate non-operational water sources, especially those needing minor repairs. The need for encouraging more rainwater harvesting initiatives, especially sand dams which are less prone to pollution and high evaporation losses, as has been well demonstrated in the Oldonyiro Division. It is also necessary to improve on the quality of water for human consumption through provision of appropriate off-take structures, regulations and community involvement. The northern part of the district, especially Merti, requires more attention in future water developments, since at the time of the study, water provision in this area was beyond 50 km for livestock, yet there is good grazing potential. Further studies are required to link socio-cultural practices such as migratory patterns of the pastoralists and the location of "range boreholes" to any future planned water developments, as this has a bearing on the grazing resources. Detailed long-term surveys to document the number of people and livestock accessing specified strategic water points are also necessary, especially to capture the most critical drought periods. The lessons learnt from Isiolo can be transferred to other drought-prone ASAL regions of Africa.

LITERATURE CITED

Adom, D.; Diallo, O. S.; Kemyou, C.; Kraidi, J.; MacKay, H.; Metawie, A. F.; Sisay, S. 2001. *Comparative review of water policy in several African countries: Identification of common emerging themes and issues*. Working Document, African Water Forum, Nairobi, Republic of Kenya.

APD (Animal Production Department). 2000. *Annual Report - 2000. Ministry of Agriculture and Rural Development.* Nairobi, Republic of Kenya: APD.

Bake, G. 1993. Water Resources. In: *Range Management Handbook of Kenya. Volume II, 5. Isiolo District,* eds. D. J. Herlocker; S. B. Shaaban; S. Wilkes. Nairobi, Republic of Kenya: Ministry of Agriculture, Livestock Development and Marketing. pp. 73-90.

Chabari, F. 1993. Livestock Marketing. In: *Range Management Handbook of Kenya. Volume II, 5. Isiolo District,* eds. D. J. Herlocker; S. B. Shaaban; S. Wilkes. Nairobi, Republic of Kenya: Ministry of Agriculture, Livestock Development and Marketing. pp. 117-137.

CBS (Central Bureau of Statistics). 1999. *Population and Housing Census.* Ministry of Planning and National Development, Nairobi, Republic of Kenya: CBS.

CETRAD. 2003. *Characterization of the ASAL of Kenya*. Nanyuki, Republic of Kenya: CETRAD.

Davies, B. 1996. *GIS: A Visual Approach.* Santa Fe, USA: Onward Press.

ECA (Economic Commission for Africa). 2000. Safeguarding Life and Development in Africa. A Vision for Water Resources Management in the 21st Century. Africa Caucus Presentations. Second World Water Forum, March 18, 2000. The Hague, the Netherlands. Addis Ababa.

ENNDA. 2002. Ewaso Ng'iro North River Catchment Conservation and Water Resources Management Study. Main Report. Ministry of Agriculture and Rural Development, Nairobi, Republic of Kenya: ENNDA.

ESRI (Environmental Systems Research Institute). 1996. "ArcView GIS. The Geographic Information System for Everyone." CA, USA: Environmental Systems Research Institute, Inc. Redlands.

Gichuki, F. N.; Liniger, H.; Schwilch, G. 1998. Knowledge about Highland-Lowland Interactions: The role of a natural resource information System. *Eastern and Southern Africa Geographical Journal.* Vol. 8, Special Number. pp. 5-14.

Gichuki, P. 2004. *Development challenges in ENNDA Region.* UNCRD-ENNDA Training Workshop Stakeholder Consultation in Regional Development Planning and Plan Preparation in the Ewaso Ng'iro North Development Basin, Nanyuki, Republic of Kenya.

Gould, J.; Nissen-Petersen, E. 1999. *Rainwater Catchment Systems for domestic supply. Design, construction and implementation.* U.K. Intermediate Technology Publications.

Government of Kenya. 2003. *Economic Recovery Strategy for Wealth and Employment Creation (2003-2007).*Nairobi, Republic of Kenya: Government Printer.

Guleid, A. A. 2002. Water-harvesting in the Somali National Regional State of Ethiopia. In: *Workshop on the Experiences of Water Harvesting in Drylands of Ethiopia: Principals and Practices,* eds. M. Haile; S. N. Merga. Dryland Coordination Group. DCG Report No.19. pp. 45-49.

Herlocker, D. J., 1994. "A survey method for classification of range condition. Range Monitoring Series No. 1." *Range Management Handbook of Kenya. Volume III, 7* Republic of Kenya, Ministry of Livestock Development.

Herlocker, D. J., Shaaban, S. B. and Wilkes S. 1993. *Range Management Handbook of Kenya. Volume II, 5. Isiolo District.* Nairobi, Republic of Kenya: Ministry of Agriculture, Livestock Development and Marketing.

Hussain, I.; Biltonen, E.; Bhattarai, M. 2001. Pro-poor intervention strategies in irrigated agriculture in Asia: Brainstorming on research design (Report on Regional Workshop Discussions). In: *Managing Water for the Poor,* eds. Hussain and Biltonene. Proceedings of the Regional Workshop on Pro-poor Intervention Strategies in Irrigated Agriculture in Asia, August 9-10, 2001.Colombo, Sri Lanka: IWMI. pp. 1-24.

Jaetzold, R.; Schmidt, H. 1983. *Farm Management Handbook of Kenya. Vol. II/B. Central Kenya.* Nairobi. Republic of Kenya: Ministry of Agriculture.

IWMI (International Water Management Institute). 2000. *World water supply and demand 1995 to 2025*. International Water Management Institute, Colombo, Sri Lanka: IWMI. www.cgiar.org/iwmi/pubs/WWVisn/WWSDOpen.htm

Langat, R. K.; Mwangata, J. H. N. 1994. Range Management in Kenya: Progress and Status. In: *Range Management Handbook of Kenya. Volume 1.1: Introduction to Rangeland Development in Kenya,* eds. D. Herlocker; S. B. Shaaban; K. S. A. Buijot. Ministry of Agriculture, Livestock Development and Marketing, Nairobi. Republic of Kenya. pp. 1-10.

Lester, B. 1985. Hydrogeology of Eastern Isiolo District. EMI ASAL Program. Embu.

Mati, B. M. 2002. *Community water developments through rainwater harvesting in Laikipia, Isiolo and Garissa Districts of Kenya.* Project notes. Kenya Rainwater Association, Nairobi, Republic of Kenya.

Mati, B. M. 2003. *Water Source Assessment and GIS Mapping: Isiolo District.* SoS Sahel International, Meru and the District Water Office, Isiolo.

MoA&LD (Ministry of Agriculture and Livestock Development). 2002. *Report of Agriculture and Livestock Development.* Isiolo District Livestock Division. Isiolo. MoA&LD.

MoW (Ministry of Works). 1962. An investigation into the water resources of the Ewaso Ng'iro Basin, Kenya, 1958-1961 (Technical Version). Hydraulic Branch, Report No. 4. Nairobi, Republic of Kenya: MoW.

MoWD (Ministry of Water Development). 1991. *Isiolo Water Resources Assessment Study* (WRAP). Main Report. Water Resources Assessment Section, Ministry of Water Development. Nairobi, Republic of Kenya: MoWD.

MoWRD (Ministry of Water Resources Management and Development). 1999. *Sessional Paper No. 1 of 1999 on National Policy on Water Resources Management and Development*. Nairobi, Republic of Kenya: MoWRD.

MoWRD (Ministry of Water Resources Management and Development). 2002. *Unpublished records* at the District Water Office, Isiolo.

Natea, S. 2002. The experience of CARE: Ethiopia in Rainwater harvesting systems for domestic consumption. In: *Workshop on The Experiences of Water Harvesting in Drylands of Ethiopia: Principals and Practices*, eds. M. Haile; S.N. Merga. Dryland Coordination Group. DCG Report No.19. pp.19-28.

Nega, H.; Kimeu, P. M. 2002 Low-cost methods of rainwater storage. *Results from field trials in Ethiopia and Kenya.* Technical Report No. 28. RELMA, Nairobi, Republic of Kenya: RELMA.

Nissen-Petersen, E. 1996. *Groundwater dams in sand rivers*. UNDO/UNHCHS (Habitatat). Myanmar.

Nissen-Petersen, E. 2000. *Water from sand rivers. A manual on site survey, design, construction and maintenance of seven types of water structures in riverbeds.* RELMA. Technical Handbook No. 23. Nairobi, Republic of Kenya: RELMA.

Ormsby, T.; Napoleon, E.; Burke, R.; Groessl, C.; Feaster, L. 2001. *Getting to know ArcGIS desktop. Basics of ArcView, ArcEditor and ArcInfo*. Redlands, Ca. ESRI Press.

Pratt, D. J.; Gwynne, M. D. 1977. *Rangeland management and ecology in East Africa.* New York, USA: Robert E. Krieger Publishing Company.

Republic of Kenya. 1992. ASAL development policy. Ministry of Arid & Semi-Arid Lands. Nairobi, Republic of Kenya.

Republic of Kenya. 1993. *Range Management Handbook of Kenya Volume II, 5.* Ministry of Agriculture. Livestock Development and Marketing, Nairobi, Republic of Kenya.

Republic of Kenya. 1994. *Range Management Handbook of Kenya Volume I.* Introduction to Rangeland Development in Kenya. Ministry of Agriculture. Livestock Development and Marketing, Nairobi, Republic of Kenya.

Republic of Kenya. 1997. Isiolo District Development Plan 1997-2001. Office of the Vice President and Ministry of Planning and National Development, Nairobi, Republic of Kenya.

Republic of Kenya. 2001. *Poverty Reduction Strategy Paper for the Period 2001-2002.* Ministry of Finance and Planning, Nairobi, Republic of Kenya.

Rosegrant, M. W.; Ringler, C.; McKinney, D. C.; Cai, X.; Keller, A.; Donoso, G. 2000. *Integrated economic-hydrologic water modeling at the basin scale.* The Maipo River Basin. EPTD Discussion Paper No. 63. Washington DC.: International Food Policy Research Institute.

Seckler, D.; Amarasinghe, U.; Molden, D.; de Silva, R.; Barker, R. 1998. *World water demand and supply, 1990 to 2025: Scenarios and issues.* Research Report 19. Colombo, Sri Lanka: International Water Management Institute (IWMI).

Sombroek, W. G.; Braun, H. M. H.; Van der Pouw, B. J. A. 1982. *The explanatory soil map and agro-climatic zone map of Kenya.* Report No. E.I. Kenya Soil Survey, Nairobi, Republic of Kenya.

Soussan, J.; Arriens, W. L. 2003. *Poverty and water security.* Asian Development Bank. http://www.adb.org/water/theme/poverty.asp.

Tetley, A. E. 1940. *The Uaso Nyiro Hydrographic Survey*. Ministry of Works (MoW), Nairobi, Republic of Kenya: MoW.

Thornton, P. K.; Kruska, R. L.; Henninger, N.; Kristjanson, P. M.; Reid, R. S.; Atieno, F.; Ndegwa, T. 2003. *Mapping poverty and livestock in the developing world.* International Livestock Research Institute (ILRI). Nairobi, Republic of Kenya: ILRI.

Thurow, T. L..; Herlocker, D. J. 1993. *Range Management Handbook of Kenya. Volume III, 5.* Users' Guide for the Range Management Handbook of Kenya. Ministry of Agriculture, Livestock Development and Marketing (MoALDM), Nairobi, Republic of Kenya: MoALDM.

UNDP (United Nations Development Programme). 2003. *Why the drylands?* UNDP-Drylands Development Centre, Nairobi, Republic of Kenya: UNDP.

UN (United Nations) Water/Africa. 2003. Africa Water Vision 2025. Economic Commission for Africa. Addis Ababa.

Williams, C. A. J. 1966. *Geology of the Chanler's Falls area*. Geological Surveys of Kenya. Report No. 75. Nairobi, Republic of Kenya.

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