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Identifying and Dealing with the Causes of Water Shortage in Lagam Escarpment of Kerio Valley, Marakwet District, Kenya

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Abstract
In the recent years, it has been realized that water supply is on the decline in Marakwet District, Kenya, especially in the drier areas, such as the extensive Lagam escarpment and the Kerio Valley, yet water is the livelihood of the people in arid and semi arid lands (ASALS). Therefore, the limited water is causing conflicts in the course of its usage. The study thus aimed at providing intervention strategies not only to ensure water supply in the area but also lead to environmental conservation. To achieve this, the study assessed the causes of water shortage in the Lagam escarpment and the Kerio Valley and also sought to establish the attitudes and the attributes of the people towards water shortage. But for the objectives to be attained, remote sensing was used to study both surface and ground water, though it was supplemented by the use of questionnaires, interviews, observation, sampling, experimentation and mensuration. Two satellite images of the area (1986 and 2000) were presented to give a picture of change in water cover over the years. It was observed that, in the area of study, there were areas where there are many people but less water, much water but less people, much water but not potable and much water that is not accessible or available for use. Generally, deforestation and water pollution may be the leading causes of water shortage in the area, besides water losses resulting from excessive water percolation (infiltration) into the Earth's crust and water mismanagement. The study has a lot of benefits to future researchers especially those intending to study water resources in the area and to the area residents, more so if the research recommendations are implemented, such as those pertaining to community involvement in the quest for water provision and sufficiency, projects for water sourcing, water catchment protection and water management procedures.

Keywords: identifying, dealing, causes, water shortage, Lagam escarpment, Kerio valley, Marakwet district.

INTRODUCTION

From the very beginning, the total amount of water on the Earth has been constant at about 1,600 million Km^3 or 54 x 10^{45} molecules (Kop, 1991). Part of this water is not recognizable, though, because it is chemically bound to the materials on the Earth or within the crust. The present amount of free circulating water may thus be about 1358 million km^3. This may infer that the Earth's water resource is inexhaustible while in truth; there is no sufficient water for every person in the world – especially in the Arid and semi arid lands (ASALs). The worst of the situation is felt in the ASALs of the Third World, where technological applications for diversifying water resources are still very limited.

Out of the 1358 million Km^3, only 3% is fresh water while 97% is salty water found in the seas, oceans and salty lakes. If this 3% is further rationed between frozen, ground and surface water, only 0.099% of it will remain as fresh liquid water that is directly available to the world's population, meaning that it is shared among all human kind on Earth (Kop, 1991).
This paper thus attempts to assess water availability in one ASAL – The Lagam Escarpment and the adjoining Kerio Valley, in Marakwet District. It also provides suggestions on possibilities towards adequate water provision, using remote sensing applications and other supporting studies. According to Castelino and Khamala (1977), the provision of just a few cupfuls of water a day can highly contribute to the life of an ASAL inhabitant. On a similar note, Raghunath (1991) discusses a variety of aspects that pertain to water – including precipitation as a source of water – to name but just one of these aspects.

Need to Overcome Water Shortage in the Kerio Valley

In the recent years, like stated earlier, water shortage has hit Marakwet District, especially the drier areas of the district such as the extensive Lagam Escarpment and the Kerio Valley, yet water is the livelihood of the people in ASALs. The limited water that there is today is causing conflict and competition in its use, between men and between men and animals -for instance, after water (furrow water) has been 'allocated' to one member of the community for irrigation during a 'water meeting' (*Kimwar*, or a meeting held by the community in order to share out the limited water resources), any other person who advertently or inadvertently diverts the water will have to pay dearly. People have been known to lose their limbs, teeth and even ears due to wars over irrigation water.

Water shortage is at its extreme during the dry season in the ASALs of Marakwet District, such as between July and March. The situation is even harder for those who farm at the extreme ends of the Kerio Valley, near river Kerio (*Kew*). During the dry season, these people will either make do with stagnant water that is found in pools along drying up rivers, or face health problems arising from thirst. The problem is that the stagnant water (*Tangiyiy*) is shared with animals, both wild and domestic, so that its safety as far as health is concerned becomes doubtful. This is because the animals do not only turbidize the water, but also excrete in it or leave remnants of their feed in the water. Worms then may not be absent in such water, besides bacteria and algae that thrive well due to eutrophication. For this reason, stagnant water that is found in pools in the Kerio Valley, during the dry season, is always greenish, as it grows green algae amid a horde of other micro- organisms, including the dangerous Cynobacteria – all of which will be harmful to man if ingested.

Visible water shortage, such as less water in rivers or drying up of streams, as in above, make one problem, the other being water shortage resulting from unavailability of safe drinking water. During the wet season, for instance, water may flow in abundance but the water is of poor quality. This is supported by ground knowledge that the people living on the Lagam escarpment and the Kerio Valley often suffer from Typhoid and other water borne diseases. The study, therefore, assessed the effects that water shortage has on the people and their livelihood in the area of study, in an attempt to suggest ways of attaining sufficient water besides ways of mitigating water pollution problems.

LIMITATIONS OF THE STUDY

It is noteworthy that this study was limited to Kerio valley in Kenya. However, the study results and recommendations may be applicable to similar situations in Africa and beyond on the basis of the diverse literature consulted and the triangulation of various research methods.

MATERIALS AND METHODS

The Study Area

The study was conducted in Kerio Valley in Marakwet District, Kenya. Generally, the Marakwet District has been divided into three main topographical regions, which run parallel to each other in N-S direction. These are: the Highland Plateau, the Marakwet Escarpment (Lagam Escarpment) and the Kerio Valley. In terms of climate, the Lagam escarpment and the Kerio valley receive less amounts of rain ranging from 750mm to about 1000mm per year. Rainfall is trimodal with first rains occurring in March, second rains in July/August and third rains in October/November, though the rainfall varies from place to place and is generally unreliable. Evaporation is also high in the area of study being about 2400mm per year (Mason & Gibson, 1957). Thus, a larger part of the Marakwet District may be described as Arid and Semi Arid Lands (ASALs). In fact, irrigation cultivation is predominant in the Lagam Escarpment and the Kerio Valley and has been so far many years.

Winds are modest, at most in the area, with a few storms during the wet season (C*hepkiriri,* as they are called in the local language). Whirlwinds are also experienced during the dry months, but they may not be described as dust storms. As for humidity, it may be said to be low during the months of May, June, September and December, but quite high during the wet months, owing to the region’s high temperatures. The other forms of precipitation that are less accounted for in the area’s climate are frost, fog and dew, which are common in the highland plateau.

In respect to geology, precambrian basement rocks are the oldest rocks in the area of study. These comprise metamorphosed sedimentary rocks (formed by regional metamorphism during the rift valley formation) such as gneiss, schist, quartzite and marble. They are found as rock outcrops along the base of the escarpment, while their fragments litter the escarpment itself forming lithosolic soils. On the Kerio Valley floor, the basement rocks have been buried by tonnes of sediments and volcanic debris.

Old tertiary rocks are also present in the area and are represented by conglomerates, sandstones and siltstones, which are limited in extent. Similarly, volcanic rocks are also quite common in this area and they may be dated back to the mid Miocene to mid Paleocene periods (25-70 million years ago). They include basic lavas (basalts) and intermediate lavas such as phonolite and trachyte. Basalts are commonly found around the river Kerio area, besides phonolite that has build the many hills punctuating the lowland terrain of the Kerio Valley. Trachyte rock is more recent and is found on the Eastern bank of river Kerio towards Baringo East, at the foot of Mt. Tiati. Alongside the rocks, the area has alluvial fans and landslide mounds that are found along the foot of the escarpment. These stand out as rock vaults, grit or clay hills.

Noticeably, the Lagam escarpment and the Kerio Valley are endowed with minerals that are lodged in Gneiss rocks. They include green, red and pink Garnets (at Rorok hill, Kamworna and Katilit), Hematite, Chalk (at Ng’achar), Marble (at Kowow and Koitillial, around Arror) and alluvial Gold at the banks of river Embobut. Faulting on the escarpment is evident in many places, though many of the faults have been buried by alluvium. To the North Western part of Tot, for instance, there are faults that are marked by hills build of brecciated and silicated tertiary superficial deposits. These are the same faults that have been colonised by vegetation lines.

On the escarpment, vegetation is mainly sparse, sometimes lacking in certain places. The vegetation here is predominantly shrub and woodland type, where most trees are drought resistant. Fruit bearing trees are numerous in this vegetation and they include *Murkullyon,Tokometwo, Tiling'wo, Tillomwo, Tuyunwo, Tongururwo* (as they are locally known), most of which are important sources of food. Thorny trees are also not uncommon in this area. They consist of a number of acacia species and some of the fruit bearing trees, while the non-thorny woods include; *Tobong'wo* (Parasol Tree), *Ililwo* (E.A Yellowood), *Kerelwo* (Croton), *Rotyon* (Sausage Tree), *Kurion* (Teclea), *Sigowo* (African Satin Wood) and *Oron* (Tamarind), just to mention a few. The escarpment woodland graduates into a forest on the highland plateau, where deforestation threatens it.

On the valley floor, though, natural vegetation comprises tall grass and a variety of thorny bushes, acacia being on the lead. The acacia forest is particularly denser, with taller trees towards the Kerio River, just as there is more grass in the swampy portions of the valley. In both the escarpment and the valley, planted vegetation is quite prevalent. It includes the many Mango forests, cassava crops and banana plots-amid a host of other crops. Riverine vegetation is also uniquely dense and healthy in both the Lagam escarpment and the Kerio Valley. This consists of fig trees such as *sitet* (The Bark Cloth Fig), *Boryotwo* (Cape Fig) *mokong'wo* (Sycamore Fig) and *Simotwo* (the Strangler Fig)-among other trees.

In 1989, the total population of the Marakwet District lay at a figure of about 108,250 people with the highland plateau and the Lagam Escarpment having more people. The Lagam Escarpment is even more densely populated than the other regions because of its warm temperatures, enhanced safety from cattle rustlers and absence of mosquitoes. During the recent years, though, the population of Marakwet District has been decreasing, owing to family planning and emigration of people from the district to the neighbouring districts of Trans Nzoia and Uasin Gishu, especially as a result of cattle rustling. In itself, cattle rustling is a backward practice that is bend to ruin development in the area. As for the population's structure, it can be said that there are more women than men in the District because men are the ones who move out to towns and high potential areas in search of employment, besides succumbing to the wounds of the cattle rustlers' guns. In the year 2001, for instance, cattle rustlers killed about 100 men and 40 women in the area of study (Chief's account, Endo Location).

Children between 0-14 years make up about 48.8% of the population, while old people of 80 years and above contribute a marginal 1.1% of the total population (Marakwet District Development Plan 1997-2000). This means that the population has a high Dependency Ratio, especially from the children's quarters. Consequently, food production should be enhanced in the area of study and it can only be done with sufficient water.

The area's drainage forms a part of the Lake Turkana drainage basin, through the river Kerio drainage system. The main sources of water in the area of study (the Lagam Escarpment and the Kerio Valley) are rivers, furrows, springs, swamps and rainfall. The rivers originate from the forested areas of the highland plateau, and they include Embobut, Embosumer, Embomoon, Embochesegon and EmboArror – noting that 'Embo' is a Marakwet term that is synonymous to the English word river. Most of these rivers are perennial, though their flow has become seasonal so that some of them no longer reach river Kerio, where they should be draining their waters. Springs are mostly found at the foot of the Lagam Escarpment, and they are all products of sub-surface water flow, probably right from the highland plateau. Their examples include the Kipkoito Springs, Kiptegan springs, Kabetwa Springs and the Chesongoch springs, among others. Today, the water coming out of these springs has also dwindled quite a lot.

Swampy regions in the area are mainly found on the floor of the Kerio Valley and may be described as extended springs, or areas of water collection during rainy seasons. They form good grazing areas for livestock during the dry season, besides providing water for animals in grazing. Rainfall remains the overall provider of water in the area of study, though rainwater harvesting is not very well developed. The rainwater that is harvested is only by natural means so that what is stored by the Earth is what will benefit the people most. Unfortunately, deforestation in the highland plateau seems to have destroyed this natural process of ground water recharge.

Target Sampling and Data Collection

Both structured and unstructured questions were used in interviewing the people. The author, for instance, held interviews anytime, whenever and wherever respondents were found, such as at home, in their farms, at water points and even along the road. Questionnaires were administered to various people and in a case where a respondent could not read nor write, the questionnaire bearer gave aid. Questionnaires were also administered randomly as was done with interviews. Samples of water were collected from two rivers and two springs. The rivers are Arror and Embobut while the springs are Chebenow and Kiptegan springs. The various secondary data sources that were studied, as relating to the area of study and the question at hand, included: Topomaps of the region, aerial photographs, books and satellite images. Ground based photographs were also used to collect data on faulted areas where water may be found, wet spots in dry areas and dry rivers fossilised by rock boulders- among other features. In the study, both participant and non-participant observation was engaged to collect data. Observation was used to collect data on water use, stream flow, spring flow and cases of water pollution.

Remote Sensing

Remote sensing is a growing field of science that involves the measurement of electromagnetic energy that can be used to characterize the landscape – or infer properties of it. For its definition, remote sensing may be said to be reconnaissance from a distance, or the collection of information from an object without being in touch with the object. It has also been defined as the science of deriving information about the Earth's land and water areas from images acquired at a distance (Campbell, 1987). In this field of science, different sensors are used to provide unique information about the properties of the Earth's surface or shallow layers of the Earth. Examples of such sensors are, for instance, the Thermal sensors that measure surface temperatures and Microwave sensors that measure the dielectric properties of the soil (Engman & Gurney, 1996). The work of the remote sensing specialist is to interpret these remotely sensed properties of the Earth; in a way that viable information is generated.

There are four basic components of remote sensing that primly influence (limit or control) what one can measure about the Earth's surface from remotely sensed images. These are: radiation source (which may be natural or artificial); transmission path; nature of the target, and the kind of sensor that is used. Some sensors, for instance, can penetrate clouds to image what is on the Earth's surface (such as radar sensors) while others cannot image well when atmospheric conditions are unstable, as in the case of aerial cameras. Depending on the interaction of these components, various photographs and satellite images are usually produced by remote sensing. Some of these are the ones that were studied and analysed to provide information pertaining to water availability in the area of study, since remote sensing can be applied successfully to investigate both surface and sub-surface or groundwater resources.

Although remotely sensed images seldom replace the usual sources of information concerning water resources, they can provide valuable supplements to the field data, by revealing broad scale patterns not recognizable at the surface. Remote sensing records changes that take place over time and provides information (data) for inaccessible regions and water bodies.

For surface water resources, remote sensing - both aerial photography and satellite imagery, provides information on:

i) The extent of water bodies and the changes that take place in the size of a water body over time
ii) The depth of a water body
iii) Water purity
iv) Drainage patterns or stream network features
v) Surface runoff characteristics
vi) Density of water bodies
vii) Type of surface water
viii) Presence or absence of a surface water feature

Remote sensing also plays a major role in the investigation of ground water, which is an important source of water in ASALs. This is done through soil moisture mapping. Soil moisture may be defined as the temporary storage of precipitation within a shallow layer of the Earth that is generally limited to the aeration zone or the root zone. This is the moisture that forms the bulk of evapo-trasnpiration water, if it does not percolate to the phreatic (saturated) zone as ground water recharge. The origin of soil moisture may be precipitation, or underground water that attempts to escape as evaporation, through capillary forces, to the surface of the soil. Whenever a soil displays wetness, presence of ground water may be inferred.

Data Analysis

Data analysis involved analysis of GIS layered data, use of satellite images and topographical maps, presentation of ground photographs, drawing of tables and quantitative analysis (where questionnaires were concerned).

RESULTS AND DISCUSSION

Extent of Water Bodies

River Embosumer, shown on Plate 1 below, is one of the rivers that have dried up in the area of study mainly due to deforestation on the highland plateau besides sedimentation. On the other hand, Embobut River, which is one of the main rivers in the area of study, is also on the verge of bowing out of existence. In the case of River Embobut though, the culprit of river extinction is not only deforestation but also increased river water diversion via furrows and deposition of sediments by water runoff on the Lagam escarpment. Currently, Embobut River appears as shown on Plate 2 below, which is a far cry of what it was some years earlier. It should be noted that water pollution is also evident from the photograph, especially the presence of children bathing in the river.

Plate 1: The Dried Up Embosumer River

Plate 2: The Dried Up Embomut River

It is also possible to outline the extent of water bodies from a Landsat image, especially from a False Colour Composite.

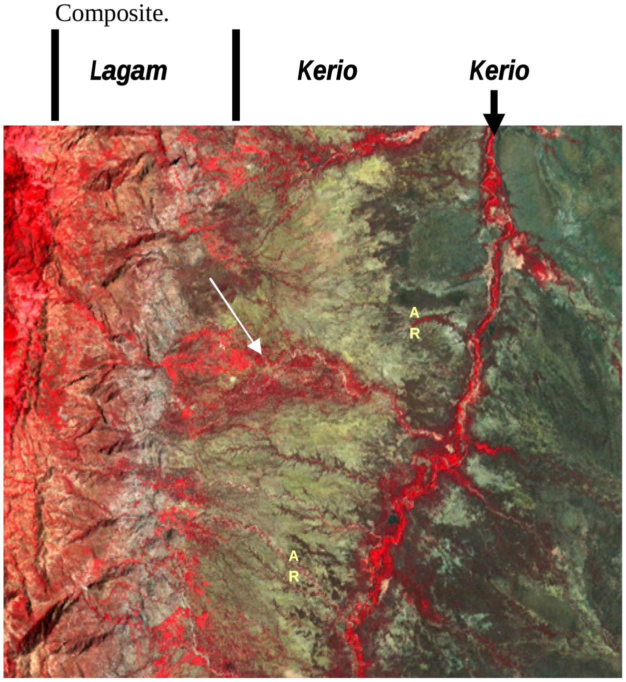

Plate 3: False Colour Composite of Landsat TM P169R059 - Jan1986 depicting Kerio River Regime Scale 1:50000

From the Landsat Thematic Mapper Image (P169R059 of January 1986 and January 2000) shown above, it is possible to outline areas where there was plenty of water in 1986 and there is none or less water now. This is done with the aid of vegetation mapping noting that in false colour composite Landsat TM image, vegetation appears red in colour. The area of the image pointed by the white arrow represents an area of dense or healthy vegetation. In the 1986 image, the dense vegetation pointed by the white arrow seems to follow two distinct lines which are most likely two adjacent river valleys. The main river valley in the pointed area is in fact quite visible noting the bright rock areas that mark the riverbanks. Consequently, it may be inferred that the river valley must have been relatively deep. This means that the riverine vegetation that existed in 1986, as depicted by the image, may have been more of tall trees along the river valley. The trees may have also been fewer. In 2000 (Plate 4), below, however, it can be noted that the riverine vegetation was dense and lacks the line placement visible in the 1986 image. The Active Rivers (AR) of 1986 had become Dry Rivers (DR) by 2000.

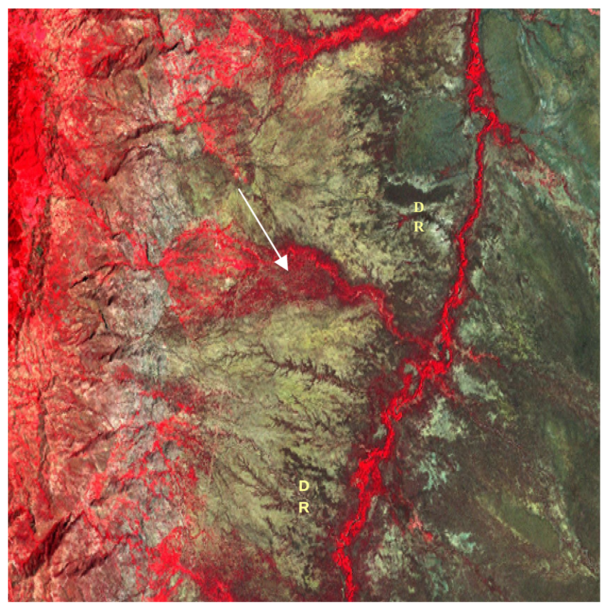

PLATE 4: False Colour Composite of Landsat ETM P169R059 - Jan2000 depicting Kerio River Regime Scale

Several things may have happened to this riverine vegetation over the years. The main river valley and its tributaries may have become sedimented so that a swamp developed on the drainage system replacing the initial riverine vegetation. Usually as a river becomes sedimented, it reduces in depth and takes on the shape of a flood plain which is a wide area covered by sand. From ground truthing, many of the main rivers in the study area have shrunk in size, some even drying up completely. River Embobut, for instance, is drying up and is lined by swampy vegetation in many parts of its course. It must be noted that the extensive bright red areas to the western side of the area covered by the images is the highland plateau that is covered by forests and is not part of the study area.

Possible Depth of Water Bodies

Due to the high levels of water runoff that are experienced in the Lagam Escarpment, most rivers and streams, in the area of study, have been filled with sediments. From the enhanced Landsat Thematic Mapper image shown below (Plate 5), it is possible to outline areas of dense vegetation as they stand out as extensive red patches, with the exception of the highland plateau where dense vegetation prevails. These areas also denote points of shallow water such as rivers that have filled up with sediments, converting to swamps. On the other hand, areas of deep water stand out as thin red lines. This argument stems from the fact that deep water occupies narrow valleys or depressions due to active vertical water body erosion. As a result, such valleys have steep banks that may not accommodate dense vegetation hence development of thin vegetation lines. Areas of shallow water in the image have thus been designated by the letters SW (Shallow Water) while areas of deep water have been shown by the letter DW (Deep Water). Several sections of the Kerio River, for instance, are deep as indicated by the thinness of the vegetation line surrounding the river.

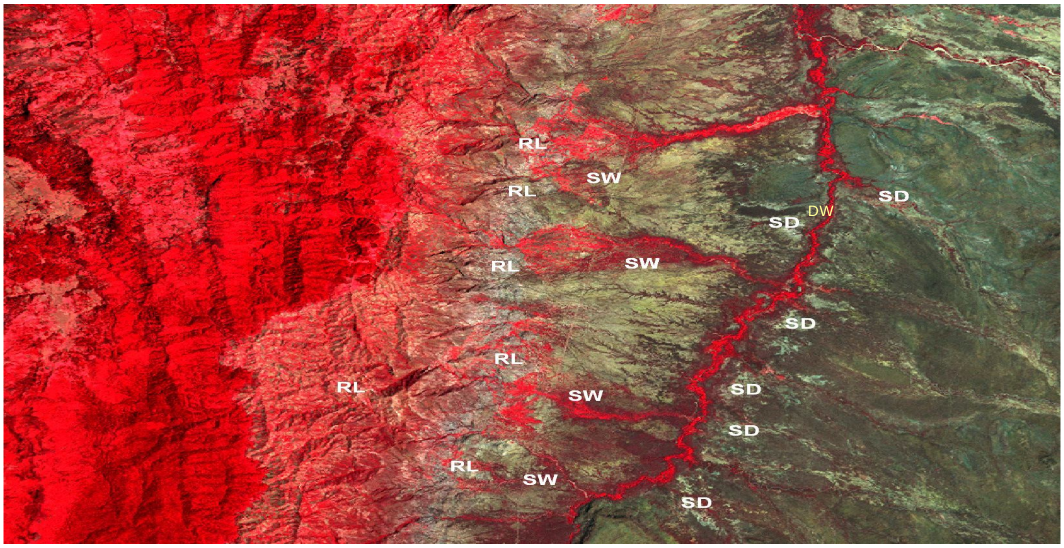

PLATE 5: False Colour Composite of Landsat ETM P169R059 - Jan2000 depicting Kerio River Regime and Geo-Hydrologic features Scale 1:100,000

Density of Water Bodies

Here, active water bodies were assessed in terms of numbers without necessarily looking at their area coverage. From the Landsat thematic mapper images shown below (Plates 6 and 7) change in the density of water bodies can be seen between 1986 and 2000. In 1986, for instance, and according to the Landsat TM P169R059 of January 1986, the number of active rivers seems to have been more noted by the number of streams joining the Kerio River. The Lagam escarpment also seems to have had many active streams dissecting it and must have boasted of dense vegetation as seen by its brightness in the red section. In 2000 (Landsat TM P169R059 of January 2000), the area shows lots of change though the image seems to have been taken during a time of heavy precipitation. Streams and rivers appear to have decreased in number with some even bowing out of existence. This can also be confirmed from plates 3 and 4 used elsewhere in this paper where rivers which were active in 1986 (AR) ceased to be active in 2000 as they dried up (Dry Rivers - DR). In the 1986 image thus, there are about thirteen countable rivers that drained river Kerio from the area of study as compared to only about ten reaching River Kerio in 2000.

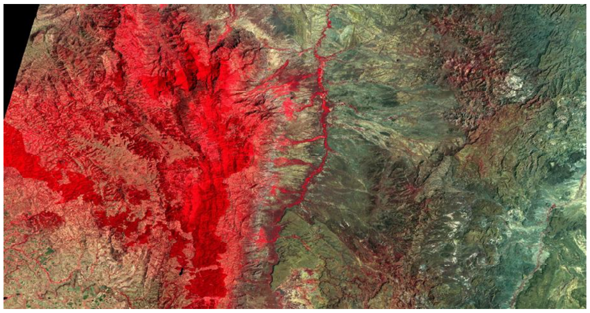

Plate 6: False Colour Composite of Landsat TM P169R059 - Jan1986 depicting Kerio River Regime Scale 1: 300,000

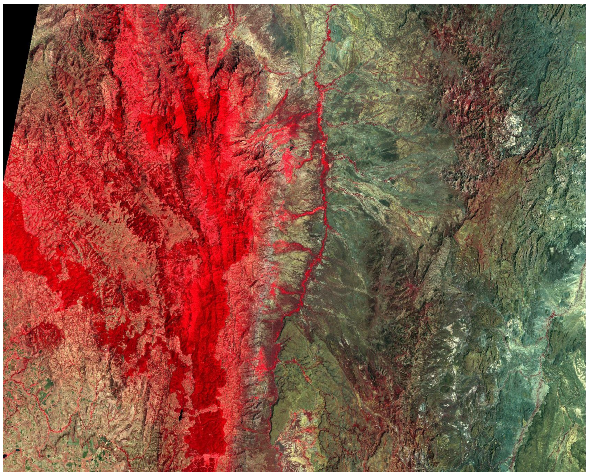

PLATE 7 : False Colour Composite of Landsat ETM P169R059 - Jan2000 depicting Kerio River Regime

It should be noted that a normal colour aerial photograph could also be used to show the purity of water in an area.

Types of Surface Water

The area of study has two main rivers, which are Embobut and River Arror. The rest of the rivers are small and seasonal though some of them occupy oversize valleys, suggesting that they were very large rivers in older times. These other rivers include: EmboArror, EmboMuchukwo, EmboKipyebo, EmboKitinos, EmboMon, Enou, EmboSumer (Katupe River) and EmboChesegon, which is at the boundary of Marakwet and West Pokot Districts.

Springs are also common in the area of study and the main ones include: Kiptegan springs, Chebenow springs, Kabetwa springs, Chesongoch and Luguget springs- among others. Interestingly, the springs have become seasonal at most, with some ceasing to flow during the dry season. Like the area's rivers, the springs also depend a lot on ground water recharge in the highland plateau, a process that is being incapacitated by deforestation.

The Kerio valley floor vaunts of a number of swamps- some large, some small. The main swamps in the area include the ones around Koibirir Hill, along river Embobut, around Kabetwa, Chesongoch and along River Kerio. As for their origin, it may be said that the swamps are continued springs or wet areas that have been created by river floods or accumulated rain water. Whichever the case, swamps form important grazing areas in the area of study.

Anthropogenic water bodies, such as dams, ponds, wells and boreholes are almost non-existent in the area of study, implying that artificial water harvesting has not been fully engaged. Information on the types of surface water in the area of study was deduced from topographical maps, secondary data, satellite images and ground study.

CONCLUSION AND RECOMMENDATIONS

It is true that the area of study is facing water scarcity and there is need for adequate supply of potable water. This then means that all need to join hands to seek a means of aiding sufficient water supply, noting that the provision of just a few cupfuls of water a day can highly contribute to the well being of an ASAL inhabitant (Castelino & Khamala, 1977). To achieve such a provision, the following must be attempted in the study area:

Aforestation of Water Catchment Areas

This can be done using non-timber tress such as the various species of fig – for instance, *Boryotwo, Mokong'wo, Simotwo, Lokorwo* and *Moyti*, besides a number of weevil susceptible trees such as *Mboryon, Korbu*, *Bonbonet* and *Moseswo* (as they are known locally) **–** among others.

Digging of Boreholes

Boreholes can be dug in the valley floor and the escarpment plateuxes, which are often adjacent to rivers. These boreholes are important because they can supply water during the many dry seasons of the area of study.

Construction of Dams

This is a good way of saving much of the water that reaches the earth as rainfall. Without this provision, all potential rainwater may simply flow away uninhibited as water loss. In the Lagam escarpment, dams could be constructed on rivers Arror and Embobut, where the rivers are constricted.

Encouraging Water Furrow Management

To avoid water losses in furrows, the furrows should be deepened and their number reduced, especially from the main rivers. This way, water in the main rivers could reach the people downstream, lessening wars over irrigation water. Water "drinking" plants should also be removed from around water bodies.

Encouraging Clean Water Use

In the study area, where water does not belong to anyone but the fox, water pollution is quite prevalent. This in turn has led to water shortage as water becomes unsafe for drinking. Clean water use should be encouraged in the area through the use of by-laws, water guards and water custodians, besides carrying out campaigns aimed at water protection through good hygiene. This is where the construction of pit latrines in the area should be emphasized.

Construction of Ground Water Reservoirs

In the escarpment where water tables are hundreds of meters deep, for instance in Kaben, Kowow, Kamariny, Kapsogom, Sibow, Kipyebo, Karel, Koitilial and other escarpment villages, ground water reservoirs should be constructed, using cement, to store water. Here, cement pavements or natural rock surfaces may be used to trap the rainwater, which is then directed into the reservoirs.

Construction of Sand Dams

This is where sediment-choked rivers may be dug at their lower points, so that water can seep in from both the upper and the lower courses of the river. Alternatively, sand harvesting could be encouraged among the local people so that the sediment-chocked rivers are dredged without too much financial strain.

Poking of the Wet Spots Identified by Remote Sensing

Since remote sensing has shed light on the various wet spots in the area of study, through vegetation and rock lineament mapping, these wet points, besides the imaged rivers should be drilled so that water can ooze out naturally from them. If this is done, the local people will have succeeded in utilising ground water to its fullest, unlike in the present time.

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