IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)
e-ISSN: 2319-2402,p- ISSN: 2319-2399.Volume 11, Issue 6 Ver. II (June. 2017), PP 72-79
www.iosrjournals.org

Climatic Trends In Relation To Land Use Change in the Mount Marsabit Region of Marsabit County, Kenya

Mulinya. C.[1]
[1.] *Masinde Muliro University of Science and Technology*

Abstract: *Climate change has had an impact on land uses and consequently land use changes have impacted on climate in the Mt. Marsabit area of Marsabit County. This study was conducted to establish the impact of climate change on land uses in Mt. Marsabit in Kenya .Climate data was collected for a period of 50 years (1960 -2010), the data was mainly for rainfall amounts and temperature figures. This was collected on monthly basis. Land use data was collected using land sat imageries for the years 1973, 1986 and 2000.Climate data was done using SPSS to generate graph that showed the trends in climate over the period of study. Land use data was analysed using Geographical Information Systems (G.I S) to find out the changes over the period of study. The study established that there was a decline in rainfall amounts of approximately 5.18 mm per annum and an increase in temperature amounts of about 0.05 ^{0} c. On land uses forests have decreased in acreage whereas agricultural land, urban areas and rangelands have increased in acreage over the period under study. Suitable environmental conservation measures such afforestation, reforestation and agroforestry and other sustainable management practices have been done to ensure environmental sustainability in the area.*
Key Words: *Climate Change, Land use, G.I.S*

I. Introduction

Climate is considered a major factor in the natural processes and human activities in any ecosystem. Climate is a factor in surface runoff, soil moisture, soil development, ground water, vegetation type, species density and production rate, all of which are important in ecosystem structure and characteristics. The ecosystem structures and types determine the type of human activities such as animal husbandry, crop agriculture or wood harvesting in any given area on the earths surface (Bake, 1983).In developing countries, such as Kenya, land use changes and population growth rates are major environmental issues of concern. With high population growth in the tropics, demand for land resources for production remains high. This often occurs at the expense of forests and other vegetation types especially in sensitive catchment areas. In the process, inappropriate land use change occur leading to a decline of productivity of the tropical ecosystems (Campbell *et al.*, 2003).In the arid and semi-arid lands (hereafter referred to as ASALs), rainfall is very variable while the other climate elements remain fairly constant. Due to rainfall variability and/or fluctuations, ASAL ecosystems tend to be very fragile and may be susceptible to permanent destruction by unchecked human activities such as felling of trees, overgrazing, forest fires, over population and poor tillage of land (Edwards *et. al.*, 1979).

The ASALs account for about 80% of Kenya land surface and they are usually dry and hot with clear skies and high temperatures of about 38 degrees centigrade. ASALs support about 25% Kenya's human population, 60% of livestock population and the largest proportion of wildlife (GOK, 1994). ASALs are characterised by low erratic rainfall of up to 700 millimetres per annum, frequent droughts, high temperatures, and intense radiation. Soil conditions include low moisture holding capacity, high infiltration rate and low content of organic carbon and association of vegetation and soils. In the ASALs, the main challenge for sustainable development is the availability of water due to low and unreliable rainfall as well as high evapotranspiration rates and poor management practices. The ASALs are associated with very low rainfall or none at all in a year. These limit vegetation cover and there is constant inadequacy of grass for livestock and wildlife and also not favourable for human settlements (Bake, 1983). Conveniently, climate studies are usually carried out based on either temporal or spatial scales. This is mostly due to the fact that climate represents the average weather conditions (the expected weather conditions) of an area. Temporal studies encompass the investigation of climatic elements over time. When this is done over a year, it enables us to appreciate the climatic characteristics of an area including the specification of given wet or dry season, hot or cold season for that specific area. Spatial variations of climate on the other hand represent the climatic differences over space.

Macro scale temporal climate variation (which is reasonably persistent) may be attributed to the modification of the earth's surface and atmosphere by humans. This modification could result from removal of vegetation cover through felling of trees, overgrazing, agriculture, urbanization, and pollution. Modifications of the earth's surface disturb the established ecosystems and this usually requires readjustments. The readjustments tend to affect negatively the fragile ecosystems especially in the ASALs in terms of land carrying capacity, land productivity and environmental sustainability. The ASALs of late have been receiving increased pressure in the form of new immigrants from the high potential lands due to increasing population pressure. These immigrants tend to import unfriendly sedentary practices, which tend to upset the sensitive environmental equilibrium in the ASALs(Michael, 2003).

Deforestation alters the hydrological cycle potential, decreasing the amount of groundwater and moisture in the atmosphere. Shrinking forest cover lessens the landscape capacity to intercept, retain and transport precipitation. Instead of trapping precipitation, which then percolates to ground water systems, deforested areas become sources of surface water runoff, which moves faster than the subsurface flows (Michael, 2003).Deforestation contributes to decreased evapotranspiration, which lessens atmospheric moisture precipitation levels and affects the precipitation levels from the deforested areas as water is not recycled to downwind forests but is lost in runoff and returns directly to the oceans(Michael, 2003).

Mount Marsabit is the main water catchment for the people of Marsabit county. All the communities living around the mountain obtain water from the wells and springs fed by the forest ecosystem. The forest is the only source of water, grass and forages for livestock during the dry spells, which are sometimes prolonged. The forest is supported by the relatively good rainfall conditions, which in turn affects the water supply in the mount Marsabit environment. The forests are faced with destruction from overgrazing, encroachment and increased demand for firewood and building materials (FHI.2001). There is therefore the need to develop an understanding of the problem and tools to manage sustainably the natural resources of the area.

II. Research Methodology

2.1 Study Site

Marsabit mountain is located between latitude 2^0 19˙ North and 37º 59´ East. The mountain covers approximately area of 2100 square kilometers. It is referred to as the Green Island since it is forested receives a higher amount of rainfall and has a lower temperature than the surrounding area and which semi arid to arid. It is an isolated area in the semi arid region of Northern Kenya about 560 kilometers from Nairobi in Marsabit District. The mountain is an extinct volcano covered by a dense forest with crater lakes such as Lake Paradise and Sokote Diko. The highest point on the mountain is at 1836 metres above the sea level (See figure 1)

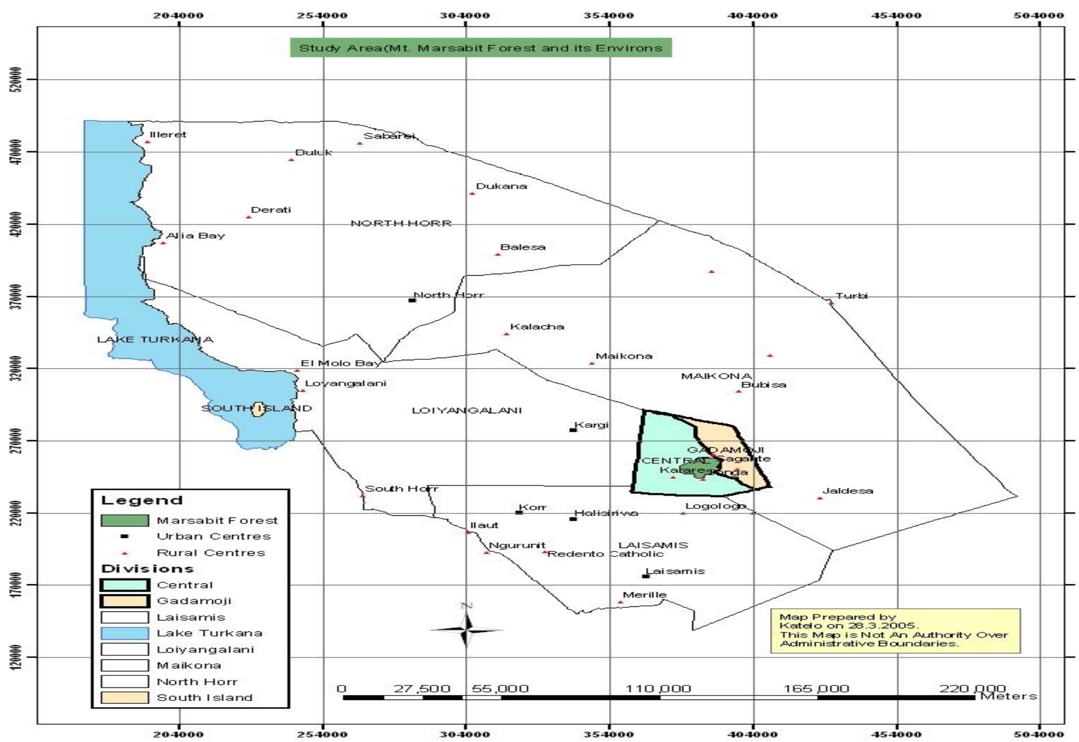

Figure 1: A map showing the study area (Mount Marsabit forests and its Environs.

The general climate is described in terms of simplified models of circulation. There is the broad equatorial low-pressure trough created by the convergence of the trade winds of both hemispheres. The main influencing aspect of climate in Mount Marsabit is the topography, which determines the amount of rainfall received in this area. Mount Marsabit receives more rainfall than the surrounding areas due to its position first as substantially high ground in the line of the mountain and its position from the East as this is confirmed by a altitudinal limit of the forest on South East of the Mountain down to 900metres to 1000metres substantially lower than that of north west side which is 1300metres to 1400metres. Mount Marsabit experiences a bimodal rainfall pattern ranging from 600 to 1000 mm per year (Bake, 1983).

Rainfall mainly occurs under the influence of the southeast monsoon, which originates from the Indian Ocean and which is relatively cool and moist. Convergence with air masses of northeast monsoon or orographic lifting of its own moisture-laden air masses by large mount Marsabit leads to instability, cooling and subsequent rainfall and mainly occurs in April and November (Edwards *et al., 1979*). The long rains (March-May) are brought by southeasterly winds. The temperatures are at average of 30^0 - 35^0 Centigrade experienced in the month of February while the long-term temperature range is 22^0-25^0 Centigrade in the month of March and July. The temperatures vary with the altitude as they decrease with increasing height. Evaporation rates are quite high with the total annual potential between 1800-2200mm.

The Mount Marsabit region and its environs being an extinct volcano has many rich well developed volcanic soils with a high retention capacity on the lower slopes and the soils are mainly Cambisols (IPAL, 1983). Some areas have moderately deep clay loams while others are stony or rocky. These soils are suitable for crop farming in areas of sufficient rainfall. Mount Marsabit region is in the agro ecological zone 3 of the district, which has high rainfall as high as 900mm per annum and low evaporation, which has induced evergreen forest. The soils are also suitable for woodlands vegetation that is characterized by deciduous thorn trees (5-15m) and tall perennial grasses.The Mount Marsabit soils are less vulnerable to soil erosion because of the forest cover and the complexes of the soils carbon and responsible for improved nutrients, water retention and the promotion of the soils aggregates leading to reduction in soils erosion and more productive rooting environment (Bake, 1983). Drainage is mainly concentrated to the East, South East and South and is generally composed of boulder streambeds. Mogut River flows westerward forms to join the Halam River. Mount Marsabit forms a hydrological divide for the surface and groundwater towards to the northwest (Bergeson, 1981). The alignment of volcanic hills and craters suggests a narrow zone of North south trending faults /fractures. The porous nature of the volcanic rocks in the area allows for most of groundwater to percolate towards the faults and fractures Geomorphologic features determine vegetation of the Mount Marsabit area. There is an evergreen to semi deciduous bush land type on Marsabit and is most extensive on the southern and the southeast flanks of this mountain reflecting on the high amounts of rainfall and the gentle slopes.(FAO, 1971).

Evergreen forests cover the eastern half of the mountain where rainfall is greatest, cloud cover most extensive and potential evaporation and temperatures least. Additional precipitation is probability obtained from moisture condensation from heavy mists, which occur frequently during the year. Such mists are important to the long-term maintenance of these forests (Edwards *et al*., 1979). Evergreen forest is dominated by *Cassipourea malosana, Olea lochstetten and Techlea simplicifolia*. This vegetation is popular with various species of wildlife such as the elephant's buffaloes.Pastoralism is the main economic activity in this area. it involves the keeping of livestock such as cattle ,sheep and goats. Pastoralism activities account for 80% of the economic activities of the Mount Marsabit region. It is most viable way of utilizing the extensive rangelands.Crop cultivation is also practiced in areas of good soils and sufficient rainfall. The Burjis refugees from Ethiopia who were later joined by the Boranas initiated it in the 1920s. Some of the crops cultivated are maize, sorghum, sweet potatoes, cassava, cabbage tomatoes and even fruits. Coffee is also grown on small scale for local consumption. The farmers are mainly the Burjis while the Rendile and the Boranas are the agropastrolists. There are 21,539 rural households that practice crop production (DDP- 1997-2001) Tourism is another economic activity in this area though on small scale because of the poor infrastructure of the area. This division has the Marsabit national reserve (2000 kilometers squared). The forest in addition to being a wildlife habitat also serves water catchments area. The common wildlife species are the elephants, buffaloes Gazelles. The buffaloes and the elephants are mainly confined to the Marsabit National Park

2.3 Methods of Data collection and Analysis

Both primary and secondary data was collected. The data obtained was in monthly rainfall amounts for all the month of the year starting from January to December. They were missing values, which were filled in by linear interpolation from the previous monthly rainfall and the preceding monthly rainfall figure, which were averaged to give the missing figures.Temperature data was used for a period of 9 years (1992-2010). Temperature data for the earlier years was unavailable due to lack of records, which could be due to the remoteness of the Marsabit area. The data obtained was in monthly temperature figures for all the month of the year starting January to December. Secondary data collected included climatic data that was retrieved from the meteorological stations within the area of study. This was mainly from Kenya Meteorological Department but more specifically data from Marsabit Meteorological Station. The land use change data was mainly from secondary sources. This data was derived from actual land use maps of this area and also from digitized maps of the Mount Marsabit area. There was the actual observation of the various land uses of the area (Ground–truthing) of the various land uses of this area. It was necessary to classify the various land uses and check whether they have changed over time. The various land uses were classified such as forestry, urban areas, rangelands or grasslands and agriculture. This was done using remote sensing techniques. The land use changes were mainly derived from the land sat MSS image of the year 1973 which was then compared with the land sat image of 1986 and 2006.This various land uses such as forestry, grasslands, agriculture and urban lands were compared in terms of their physical area as per the changes over time.

2.3.1 Rainfall and Temperature Analysis

The collected data was subjected to both quantitative and qualitative analyses using standard statistical packages. To get the trends of rainfall over this period of study, monthly, seasonal, annual and decadal analysis were done. To get the actual representation and the structure of the monthly rainfall distribution for each month for the period (1960-2010) and temperature (1992- 2010). Time series was used and particularly the moving averages technique was found appropriate for this study. For this particular study a 5-year moving average was used. Time series is appropriate in terms of its structure and distribution and it quite useful in studies that consist of observations taken at specified times usually at equal intervals or observations usually organized sequentially with respect to time. Mathematically Y1, Y2, Y3, and Yn of a certain variable represent a time series. In this study Y is the monthly rainfall and temperature, which is a function of time. Variable y is this study was a function of time (t) years and hence symbolized by Y = F (t).

2.3.2 Analysis of Land use Changes

The land use changes were analyzed using the Landsat MSS image of 1973, which was compared with that of Landsat TM 1986, and Landsat TM 2000. This was done to reveal the changes in the land use of the Mount Marsabit region. The raw images showed detailed information, which required the use of a GIS tool to interpret. For this study the main land-uses of concern were agriculture, forestry, grassland shrub lands and how they changed over time so as to be able to relate it with the changes in the climatic trends. This was done using the GIS computer programme GEOVIS to find the area under forestry, grasslands, cultivated areas, shrub lands and urban lands. This research used satellite images to obtain information on the various land uses of the Mount Marsabit and how they have changed over time. This was necessary to find out if there is any relation between changes in land use and climatic trends. This was done before the actual fieldwork and this was done using the land sat TM images (Figures 17, 18 and 19) show using bands 4, 3, and 2. This combination gives the images strong contrasting colours of red green and dark green respectively. The different colours were useful in generating of natural classes of the various land uses. Secondary data of various land uses was then used to aid the image interpretation and also show the accuracy of the land use maps of the area. Lastly,Ground Truthing was then done to get first hand information on the ground. This requires actual field visits to the population area so that in the case of the various lands uses by confirmation these biophysical resources. This actual field visit were done in this research ad the various land uses such as cultivated area, forestry, rangelands, grasslands and settlements were located. The land-cover map of the Mount Marsabit area was used to generate these land uses to be used to do the ground trothing.

III. Results And Discussions

There has been declining trend in the rainfall amounts with 5.18mm per year during this period of study in the Mount Marsabit region. The monthly rainfall trends for the period of 1960 to 2010 clearly indicate these trends.

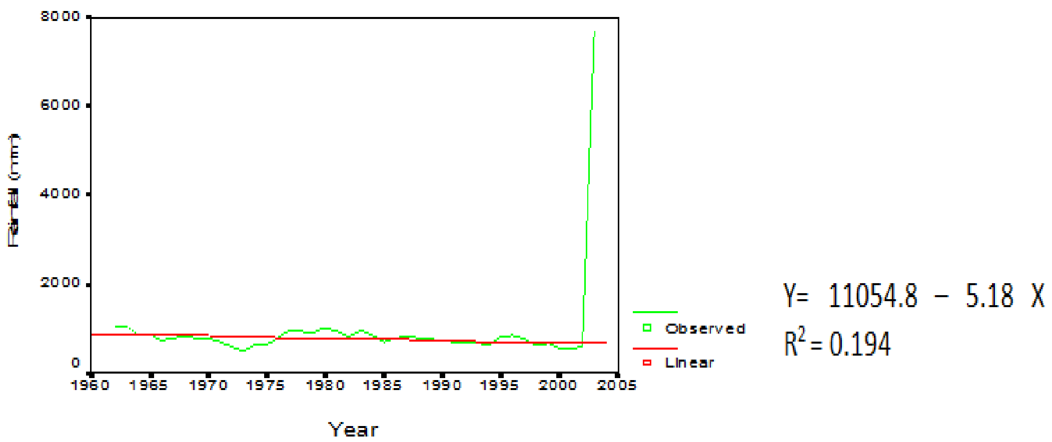

Fig 2. Total Annual trend 1960-2010

This indicates a decreasing trend in the amounts of rainfall of approximately 5.18mm for the period between 1964 and 2004. The year of 1999 had extremely low total annual rainfall amount of 99.4mm. Other years with low total annual rainfall amount include 1973 (214mm), 1975 (464.5mm), 1983 (545mm), 1999 (386mm), 1995 (314mm) and 1998 (336.6mm). 1961 recorded extremely high amount of rainfall of 1826.7mm. Years such as 1963, 1969, 1976, 1979, 1981, 1984, and 1996 recorded high amount of rainfall.

3.1 Seasonal Rainfall for Marsabit

This was done on the basis of the seasons. This region has two seasons wet season (March-May) or the long rains the rainfall amounts during this season declined by approximately3.21mm, (October-December) or the short rains had a decline of approximately 0.72mm in rainfall amounts. The dry season (January-February) had a decline in rainfall amounts of about 0.89mm while (June –September) had a decline of approximately 0.35mm in rainfall amounts. Just like the monthly rainfall trends there was a decline in the seasonal rainfall amounts during this period.

3.2 Decadal Mean Monthly Rainfall

This was mainly done to find out if there are any significant trends within a ten year period. Mainly done to verify how rainfall amounts have been over as shorter time .For this study the decades were divided into four and the mean monthly rainfall amounts for all the four decades compared for analysis. There is a general decline in the decadal rainfall amounts over the period of study with the exception of the 1981-1990 decade when the rainfall amounts increased to 161.3mm from the previous decade

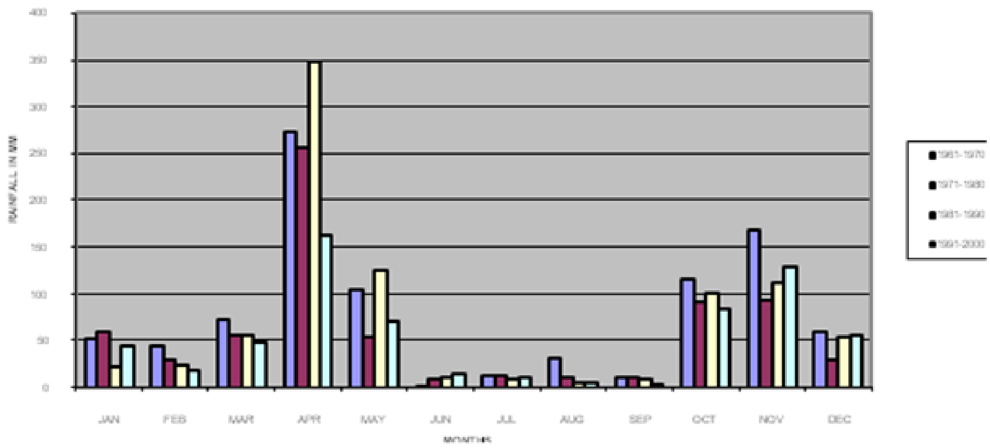

Fig 3 Decadal mean monthly rainfall

3.3 Temperature Trends

In ASAL areas temperature is not as significant as rainfall because it tends to be uniform as it is less variable. The temperature trends of Marsabit region were derived from a period of between 1992 and 2000.Generally there is a slight increase in the temperature figures this could be due the increased deforestation causing the earth surface to be bare and hence there is reduced evapotranspiration leading to a decrease in the cooling effect of the atmosphere and thus higher temperatures. Increase in temperatures could also have an impact on the cloud forest and hence this would affect the horizontal precipitation. This could be the reason for the declining amounts of rainfall as there is reduced evapotranspiration in this area.

3.3.1 Mean Monthly Minimum Temperature

There is generally an increasing trend in the maximum temperature figures for all the month of the year 1992 to 2000 indicates this with the exception of the month of February and May, which have a decline in the temperature figures. The linear distribution pattern shows constant temperature figures, as there are no extremities (See appendix

3.3.2 Mean Monthly Maximum Temperature

Just like the minimum temperature there is an increasing trend in the maximum temperature figures for this region. All the month of the year of 1992 to 2000 indicate this with the exception of January, June and July which show declining trends.

3.3.3 Mean annual maximum and minimum.

Total annual temperatures are generally increasing slightly during this period of approximately 0.01 and 0.05 for maximum and minimum temperatures respectively. This study cannot fully describe the exact changes for temperature because data used was for a very short period.

3.4 Land Use Changes

From the G.I.S interpretation, it is evident that there are changes in the land use. There is evidence that the forests are shrinking while the urban rangelands and cultivated areas are increasing in the area. This could be due to population increase because as per the 1979, 1989 and 1999 population census there is a clear indication that population is swelling and especially in the mountain area this leads to the clearing of forests to get land for cultivation. Since many inhabitants of Mt. Marsabit are pastoralists it is also possible that they are keeping large numbers of animals which are likely to overgraze and hence destruction of forests and hence destruction of the forests and thee increases of grasslands.

Urban or built up areas-This are made of intensive use land covered by structures such as cities, towns, villages strip developments along highways, transportation and communication facilities and areas such as those occupied by mills, shopping centres, industrial and commercial complexes. The Mount Marsabit had an initial area of about 3.5 square kilometres in 1973 increasing at 35% to 4.75 square kilometres in 1986 and steadily at 36.8% to 6.5 square kilometres in the year 2000.The urban area has increased with a rate at 85.7% from the year 1973 from 3.5 square kilometres to 6.5 square kilometres.

The Mount Marsabit region is experiencing a steady growth of urban centres such as the Marsabit town, which serves as an administrative, commercial educational and even cultural centre. Other smaller centres such as Karare and Songa are also growing very fast. This rapid growth could be attributed to better facilities of the towns and favourable climatic condition of mountainous region hence also increase in the population. This has impacted on the climate of this area because creation of urban settings implies that there is clearing of the forest, which would lead to decrease in precipitation since the amount of evapotranspiration is also reduced. Secondly there is increase in the runoff amounts due to the change of the surface, which is mainly concrete, and water cannot percolate which could lead to flooding in the drier lowlands (see table 1)

Agricultural land - This is the land use confined the production of food. This mainly involves uses such as cropland and pasture, ornamental and horticultural farming. In 1973 this region had 50 square kilometres of agricultural land increasing at 100% to an area of 100 of square kilometres and also steadily increased to 200 square kilometres at 100%.

Agricultural activities in the Mount Marsabit have increased by 400% over time this is due to the favourable climatic conditions on mountain slopes and also improvement in the technology and skilled manpower such as the KARI Marsabit, which trains farmers on crop improvements. The main areas where agriculture is thriving well include the Songa area where horticultural crops such as cabbages, tomatoes and fruits are grown. Agricultural activities are expanding due to population increase and hence this has led to the clearing of the forests to create land for cultivation. This has effects on the climate because the transpiration rates and carbon sinks of cultivated crops is less as compared to that of the forests and this would affect the rainfall amounts and temperature of this region. Secondly cultivated areas are not as permanent as forests because their growth period is shorter as compared to that of forests and this will affect the albedo of the surface and affect the incoming insolation.

Rangelands- the Mount Marsabit rangelands have been increasing over time. In 1973 the area was 1840 square kilometres increasing to 1860 square kilometres in 1986 to 1885 square kilometres in 2000 at 1.1% and1.3% respectively. The increase has not been as adverse as the other land uses because there was an increase was only about 2.4%. This is land where potential natural vegetation is predominantly grass, grass like plants, forbs or shrubs and where natural grazing occurs. Since Mount Marsabit area especially the lowlands are predominantly inhabited by pastoralists the area under rangelands is constantly increasing. This could be due to overstocking of animals, which seek grazing from the forested area hence the conversion of forests to grazing lands.

Forestry-These are areas that have tree crown over an areal density. Unfortunately for the mount Marsabit region the forest cover has been decreasing over the years. In 1973 the area under forest was 190 square kilometres then reduced to 175 square kilometres in the year 1986 at 7.9% and has reduced to 160 square kilometres in the year 2000 at 8.6%. The Mount Marsabit forest has been shrinking over time this can be attributed to the increase in the human population of the area and hence led to increase in demand for agricultural land, wood fuel, settlements and even pasture for the animals.

Table 2: Land Use Changes in Mount Marsabit Region

Type of land use	1973	1986	2000
Agriculture	50	100	200
Forest	190	175	160
Rangelands	1840	1860	1885
Urban	3.5	4.75	6.5

Source: Researcher

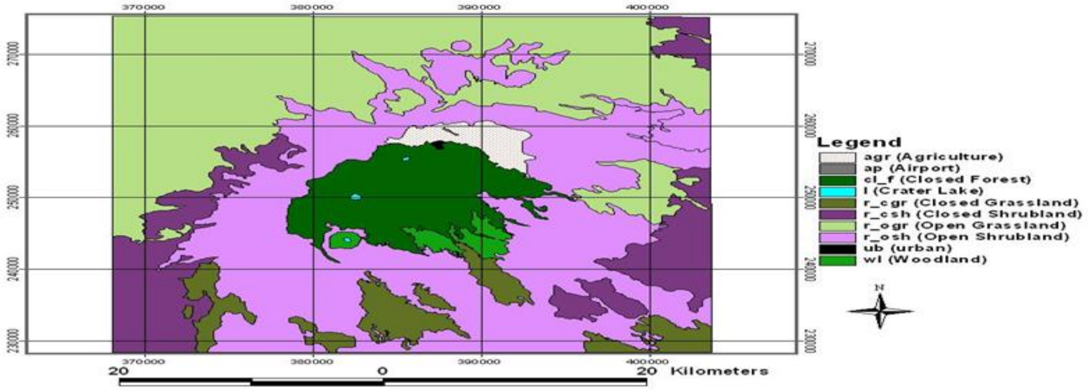

Fig 4 Land use and land coer map of Mount Marsabit of 1976

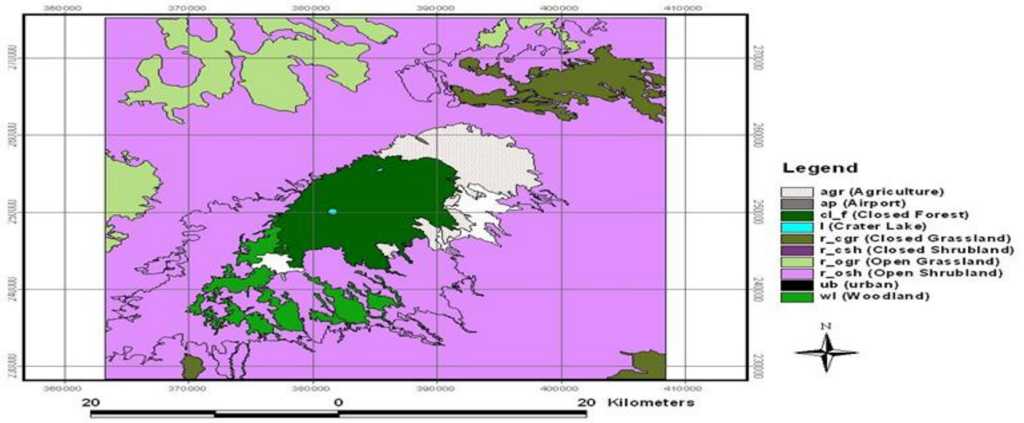

Fig 5 Land cover and land use change map of Mount Marsabit of 2000

IV. Conclusions And Recommendations

Mount Marsabit region is experiencing a decline in the amounts of rainfall of approximately 5.18mm and a slight increase in temperature values of approximately 0.01 and 0.05 for mean maximum and minimum respectively this could be attributed to the changes in the land use of this area. Increase in temperature has possibly led to the decrease in atmospheric moisture because of reduction in forest cover and reduced evapotranspiration rates. This in turn could have affected the locally generated rainfall generally associated with altitudinal variations and evapotranspiration. Decrease in the evapotranspiration is likely to affect the cooling effect thus the observed increase in temperature conditions.Land use changes in most cases lead to land degradation such as soil conditions, water quality, problems of accelerated erosion, and loss of soil fertility. When deforestation takes place in a certain area as the case of the Mount Marsabit this would lead to significant reduction of in the productivity capacity of the land. Increase in population is the main cause of land use changes in the Mount Marsabit area. Clearing of forests for settlements, urban lands and agriculture are the main drivers of land use change in the Mount Marsabit. This is further exacerbated by human activities such as unsustainable agricultural land use, poor soil and water management, poor irrigation practices and overgrazing. Decline in the forest cover could be possibly be explained by the increase in cultivated lands. In conclusion changes in land use especially the forest cover and cultivated lands have led to increase in temperature conditions and decline in the local rainfall conditions since the evapotranspiration rates are also low. In Africa where large population are dependent on natural resources for their livelihoods. Subsistence agriculture and pastoralism form the economy of the Mount Marsabit region and has the most direct and severe impacts on land degradation, which have consequently altered the climate of this region. The inhabitants of this region have degraded the forest and fragmented the natural ecosystems and hence reducing and affecting the biodiversity of this area. Due to an increase in livestock numbers this could put pressure on the perennial plants leading to the exposure of soil surface to soil erosion and also they would compact the soil near the water surface and this would decrease percolation and increase surface runoff and also increase the albedo, this should in turn would affect evapotranspiration rates, since much of the waters goes back to the rivers and as an effect on the local rainfall amount. The primary impacts of conversion of forested lands leads to cultivated lands are the increase in the atmospheric carbon dioxide via the losses of biomass and soil carbon to the atmosphere. When croplands replace forests the turnover of excess carbon in the biosphere decreases and sink capacity of terrestrial ecosystem decreases. When carbon dioxide amounts are altered this has effects on the local, regional and global climate by changing the energy balance on the earth surface. Land use changes affect the rates of evapotranspiration and reduced evapotranspiration would imply less cloud cover and precipitation and increased insolation.

4.1 Recommendation to Policy Makers

The following recommendations were made in effort to conserve the Mount Marsabit forest since it is a source of livelihoods of about 40000 people of this region.

(a) Reforestation and afforestration; since deforestation has already taken place in many parts of the mountain it is necessary to strategize on policies on environmental management and conservation. There is need of planting more trees that are suitable for this region in that whenever you cut any you plant another.

(b) There is need to encourage agro forestry in the Mount Marsabit area. This is land use where trees are planted in the same land management as agricultural crops as well as keeping of animals (dairy farming). This is quite a complimentary activity as the benefits accrued from this land use will be useful in the conservation of the environment without altering the natural surfaces.

(c) Protection of forests should be reinforced through law enforcement so as in turn we can protect our vast biodiversity found in the forests. This can be done through fining of offenders who destroy forests. There is need for selective cutting and felling of trees to encourage regeneration and also for the conservation of the endemic species. This would require degazeting of forest area.

(d) Creating awareness through expansion of educational programmes to the rural people. There is need to educate them on the usefulness of forests, alternative sources of fuel such as gas, electricity and even the solar cookers since the mount Marsabit region has high insolation throughout the day this would be particularly useful to them instead of extracting wood fuel from the forest. There is need for the government to put emphasis on land management and conservation policies. There is need to practice sustainable land use practices such as keeping a sizeable number of livestock to avoid overgrazing and suitable agricultural methods of farming to avoid land degradation.

References

[1] Bake, G. (1983), An analysis of Climatological data from Marsabit District of Northern Kenya-IPAL Technical Report No B-3, UNESCO, NAIROBI
[2] Borgeson, R.H (1981), A preliminary analysis of underground water from Marsabit District, Northern Kenya-IPAL Technical Report B-2 UNESCO, NAIROBI
[3] Campbell, D.J et al (2003) Root causes of land use change in Loitoktok area in Kajiado District, Kenya. Workshop paper No.19 January 2003.
[4] Edwards, K.A, Field C.R and Hogg, I.G (1979) A Preliminary Analysis Of Climatological Data For Marsabit District, Of Northern Kenya. UNESCO/IPAL Technical Report Number B-1.
[5] FAO, 1985, FAO Water shed Management Field Manual. FAO Conservation Guide Vol. 13 UN Food and Agriculture Organization, Rome
[6] FAO, 1986b Tropical Forestry Action Plan Committee on Forest Development in Tropics, UN food and Agriculture Organization, Rome
[7] Food for the Hungry International, Kenya (2001).Cooperating to save Marsabit Mountain. Report of FHI sponsored workshop to develop for saving Marsabit Mountain through inter-agency collaboration.
[8] .GOK (1994). The Kenya National Environment Action Plan (NEAP) Report
[9] Hamilton, L.S. 1996. The Role of Protected Areas in Sustainable Mountain Development, in Commission on National Parks and Protected Areas of IUCN - The World Conservation Union.
[10] Herlocker (1979) Vegetation of Marsabit District. UNESCO/IPAL Technical Report Number D-1.
[11] Herlocker, (1998) Vegetation of Marsabit District.UNESCO/IPAL Technical Report(B-1)
[12] Houghton R. A. 1993: Effectives of lands use carbon balance of terrestrial ecosystem Cambridge University Press
[13] http://www.fao.org/doc/show
[14] IPPC (1996) Climate change 1995: Impacts, adaptation and mitigation of climate change Scientific Technical Working Group II. Cambridge University Press.
[15] Mountain Agenda (, 2000) Mountain forests and sustainable Development Swiss Agency for sustainable development and cooperation, Centre for Institute of Geography.
[16] Mountain Agenda, (1999): Mountains of the World: Water Towers for the 21st Century, Mountain Agenda, Bern, 48 pp.
[17] Thurow T.L and Herlocker D.J, (1993), Range Management handbook of Kenya Volume 3, Ministry of Agriculture and livestock Development and Marketing. Nairobi
[18] United Nations Conference on Desertification, Nairobi (1997). Desertification, Its Causes and Consequences.
[19] United Nations framework Convention on Climate Change UNFCCC. First National Communication of Kenya to the Conference of Parties; Nairobi, Kenya 2002.
[20] William Michael 2003, Deforesting the Earth, University of Chicago press, Nairobi