KENYA DROUGHT
Impacts on agriculture, livestock and wildlife

NATIONS ENVIRONMENT PROGRAMME AND THE GOVERNMENT OF KENYA

Kenya Drought: Impacts on Agriculture, Livestock and Wildlife

United Nations Environment Programme and the Government of Kenya

Produced by: UNEP and the Government of Kenya
Contributors: Gordon Ojwang', Martin Shimba, Charles Situma, Dan Kithinji, Patrick Kariuki, Boniface Oluoch, Erick Akotsi and Jacob Kimani.
Cordinator: Elizabeth Khaka

Editing: G. Ojwang' and K.S. Buigut

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United Nations Environment Programme
P.O. Box 30552
Nairobi, Kenya
Tel: (+254 20) 7621234
Fax: (+ 254 20) 7623927
E-mail:cpiinfo@unep.org
Web: http://www.unep.org

Department of Resource Surveys and Remote Sensing (DRSRS)
P.O. Box 47146
Nairobi, Kenya
Tel: (+254 020) 609013/27
Fax: (+254 020) 609705
Web: www.drsrs.go.ke

ACRONYMS

ALRMP	Arid Lands Resource Management Project
ASAL	Arid and Semi-Arid Lands
AVHRR	Advanced Very High Resolution Radiometer
CETRAD	Centre for Training in Arid Lands Development
CMI	Crop Moisture Index
DRSRS	Department of Resource Survey and Remote Sensing
DEPI	UNEP Division on Environment Policy Information
DMC	Drought Monitoring Centre
DAO	District Agriculture Officer
EIA	Environmental Impact Assessment
EWS	Early Warning System
FEWS NET	Famine Early Warning Network
CBS	Central Bureau of Statistic
GIS	Geographic Information System
GOK	Government of Kenya
IGAD	Inter-Governmental Authority on Development
IRIN	Integrated Regional Information Network
KMD	Kenya Meteorological department
MRC	Mpala Research Centre
NDVI	Normalized Differential Vegetation Index
NCPD	National Cereal and Produce Board
NOAA	National Oceanic and Atmospheric Administration
RDI	Reclamation Drought Index
PN	Percent Normal
RELMA in ICRAF	Regional Land Management Unit in World Agroforestry Center
RFE	Rainfall Estimation
PSDI	Palmer Drought Severity Index
SEA	Strategic Environment Assessment
SRF	Systematic Reconnaissance Flight
SPI	Standard Precipitation Index
SWSI	Surface Water Supply Index
UNEP	United Nation Environment Programme
UNICEF	United Nations Children Fund
VI	Vegetation Index
WPF	World Food Programme
WRSI	Water Requirement Satisfaction Index

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Foreword

Over the past two decades, periods of drought in Kenya have become more frequent and prolonged, affecting an increasing number of people. One of the worst weather calamities to affect the country in recent memory was the devastating drought that affected Kenya in 2000. In response, the Government of Kenya requested UNEP's assistance to collect detailed information for developing measures to cope with future droughts. A rapid assessment was undertaken in 2000, and those results have been used as a baseline for this report, along with data collected between 2000 and 2004. Kenya Drought: Impacts on Wildlife, Agriculture And Livestock provides a detailed analysis of drought events in Kenya and their impacts on communities, agriculture, livestock, wildlife, forests and water resources.

The severity of the 2000 drought was exacerbated by widespread environmental degradation. The effects included reduced agricultural productivity, widespread food shortages, and power rationing as water levels dropped in key reservoirs, seriously undermining the country's economic performance. The report finds that the drought worsened poverty, especially among communities living in semi-arid areas of the country. The cost of drought relief supplies and livestock losses was estimated at about Ksh. 8 billion (US$110 million).

Kenya Drought: Impacts on Wildlife Agriculture And Livestock also highlights key measures to reduce poverty levels, including mainstreaming coping mechanisms for the impacts of long dry periods into short-term and long-term sustainable development planning and programmes. The report serves as a baseline for developing and implementing monitoring programmes for future weather-related disasters. It also recommends mitigation measures to address recurring droughts, including the protection of forests and water resources, raising awareness among local communities about the importance of natural resource conservation, and formulating policies and plans relevant to the most drought-affected areas.

In 2004–5 another protracted period of drought hit Kenya, severely affecting pastoralists and their livestock. The cost of this drought on lives and livelihoods will be felt for many years to come. It certainly will not be the last period of drought in the region. It is hoped that the Government of Kenya, communities and other stakeholders will find this report useful for coping better with future droughts

Achim Steiner
UN Under-Secretary General
Executive Director UNEP

Hon. Prof. Kivutha Kibwana, MP
Minister, Environment and Natural Resources
Government of Kenya

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Our sincere appreciation is extended to the District Commissioners and their Officers in all the districts visited. Without their insight and availability we would never have been able to collect the necessary data. Our thanks go to the World Food Programme (WFP) and District Livestock/Agriculture Officers in Laikipia District and Centre for Training in Arid Lands Development (CETRAD).

We would like to acknowledge many institutions including the Kenya Meteorological Department, the Forest Department, the Water and Irrigation Department, Ministry of Agriculture, the Central Bureau of Statistics, Drought Monitoring Centre, the Famine Early Warning System (FEWS), KenGen, Mpala Research Centre (MRC), Arid Lands Resource Management Project (ALRMP)

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Addendum

I. Drought impact and vulnerability 2005-2006

1. Kenya was hit by another serious drought in 2005 when this assessment report was being finalised for printing. A quick survey indicates that the expected Growth Domestic Product (GDP) of 6% forecasted by experts for 2005 was not met partly due to the depressed economic performance resulting from drought.
2. Limited rains towards the end of the 2005 short rainy season resulted in drought across Kenya. In some areas, drought was a cumulative effect of the poor long rainy season earlier in the year. The poor short rainy season resulted in crop failure, deterioration of vegetation conditions and drastic decline in the amount of water in reservoirs. Despite the good rains received during the end of first quarter in 2006, a portion of Kenya remained dry since rain distribution has been uneven, sparse and short lived. It is apparent that the impacts of the poor rains of 2005/2006 persist especially as evidenced in poor pasture conditions, inadequate water availability and continued supply of relief food to allay famine.
3. The worst affected areas cover approximately 66% of Kenya's land mass. This includes 22 districts in the Arid and Semi-arid Lands (ASAL). Of these, the worst hit districts were Turkana, Marsabit, Mandera and Samburu in the north; and Wajir and Isiolo districts in the north-central region. In these areas, between 30 and 40 percent of the population was malnourished, virtually triple the average malnutrition rate of these regions.
4. In summary, the following facts were adduced:
   (a) The gravity of the drought phenomenon, progression and severity in 2005-2006 was great and resulted in heavy losses of livestock.
   (b) The drought was most severe in North-eastern, Eastern and Coast provinces
   (c) In some areas, the 2005-2006 drought was worse in terms of economic losses compared to the 2000 drought.
   (d) About 3.5 million Kenyans were vulnerable, often incapable of meeting basic needs, particularly food requirements, and hence experienced severe malnutrition culminating in emergency relief food supplies.
   (e) At the peak of the drought, the vegetation condition as well as water supply of the affected districts deteriorated drastically causing the death of livestock and wildlife. Livestock was more affected compared to wildlife.
5. The drought ended in the first quarter of 2006 with the onset of seasonal rains, which fell in most parts of the country, including the areas affected by drought. In arid and semi-arid areas, the rains improved pasture and provided water for livestock in addition to filling reservoirs. However, the heavy rains caused flooding of the Ewaso Nyiro River in the Malka Daka area.

II. Use of Satellite Data in Drought Monitoring

A Rapid assessment of the impact of the 2005/06 droughts in Kenya was undertaken by analysing the NOAA's Advanced Very High Resolution Radiometer (AVHHR) satellite imagery in which Normalized Difference Vegetation Index (NDVI) was computed to determine drought severity. NDVI provides an indication of the vigor and density of vegetation. It is used to characterize climatic fluctuations. The values range from positive to negative with dense vegetation having a higher value than sparse vegetation. Values below 0 indicate environmental stress. The lower the value, the more severe is the drought.

6. The results of this analysis were compared with the outcome of a similar study, carried out using the same methodology, of the 1999/2000-drought episode, contained in chapter 2 of this report. Case studies were drawn from the following districts:

A. Kajiado district

7. Kajiado district is located in the Kenya southern rangelands. The impact of the 2005/06 drought devastated the district causing the majority of pastoralists to move to the surrounding districts such as Nairobi, Machakos and Makueni, among others. The NDVI analysis of the vegetation condition shows that the 2005/06 drought was less severe than the 1999/2000 drought, with NDVI anomalies of -1.9 and -2.2 respectively (figure i). Nevertheless, the district experienced hardships due to failure of the rains in preceding seasons with little time to allow the vegetation to recover.

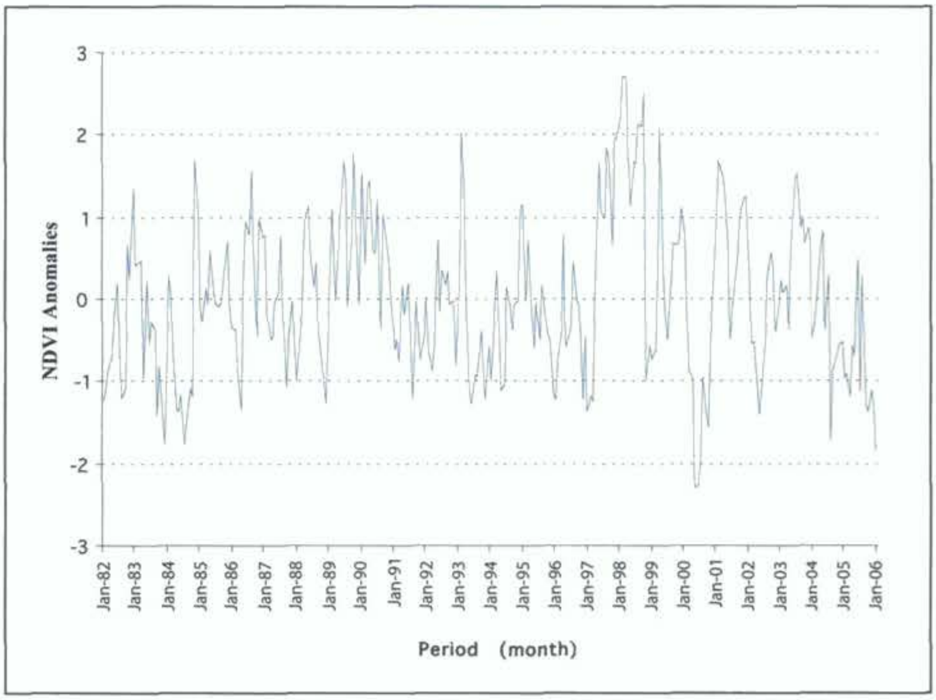


Fig. i. Monthly NDVI anomalies for Kajiado district from 1982 to 2006

B. Kwale district

8. This is one of coastal districts that experienced serious problems as a result of the prolonged drought. The NDVI analysis shows that the district was hard hit by the drought. The intensity of this impact is similar to that of 1999/2000 (figure ii).

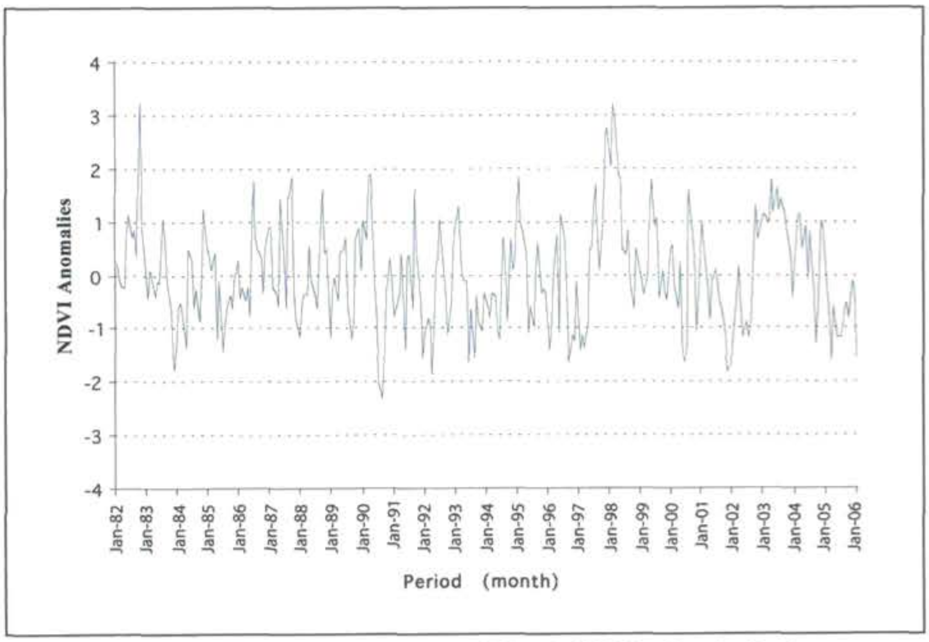


Fig. ii. Monthly NDVI anomalies between 1982 and 2006 for Kwale district

C. Isiolo district

9. Isiolo District is located in Northern Kenya, where the effect of the 2005/06 drought was also heavily felt. The NDVI results show that the district was affected by the current drought to nearly the same degree as the one experienced in 2000 (figure iii). However, the 2005/06 drought had more impacts on the district due to the failure of preceding rains that had resulted in poor vegetation conditions.

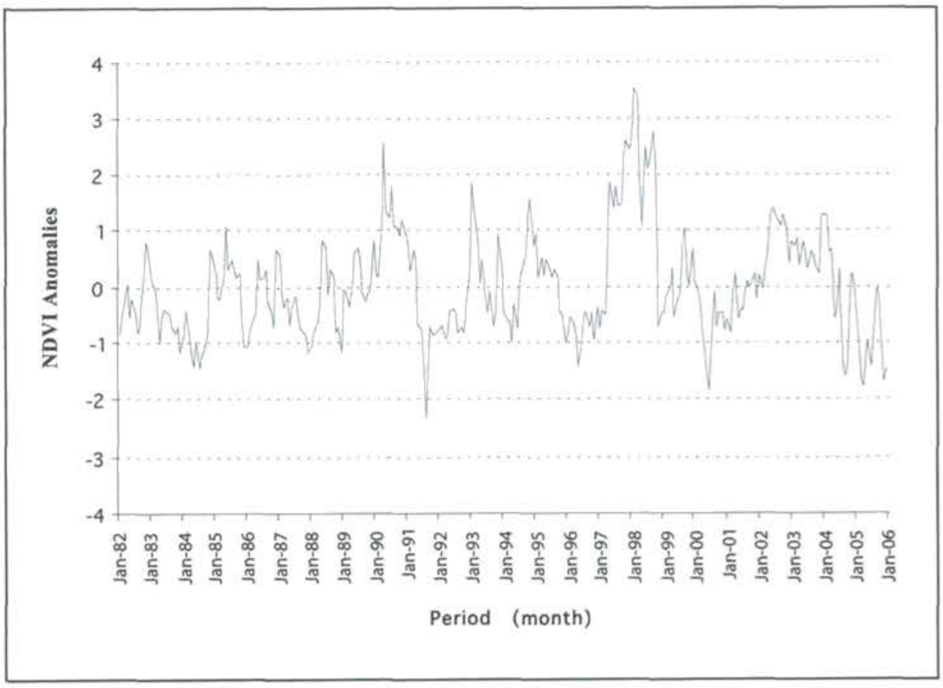


Fig. iii. Monthly NDVI anomalies between 1982 and 2006 for Isiolo District

D. Kitui/Mwingi Districts

10. These two districts were not included in the 2000 analysis but were added to the report due to public outcry on the 2005/06 drought. Inhabitants of the Kitui, Mwingi and surrounding Kamba districts reported cases of massive losses of livestock, food shortages and acute water shortages at the peak of the drought. The NDVI anomalies analysis for the Kitui/Mwingi districts indeed confirm that the prolonged drought in the preceding years exacerbated the situation and severely affected the areas. Results show that the 2005/06 drought episode was worse than that of 1999/2000 in both districts. (figure iv).

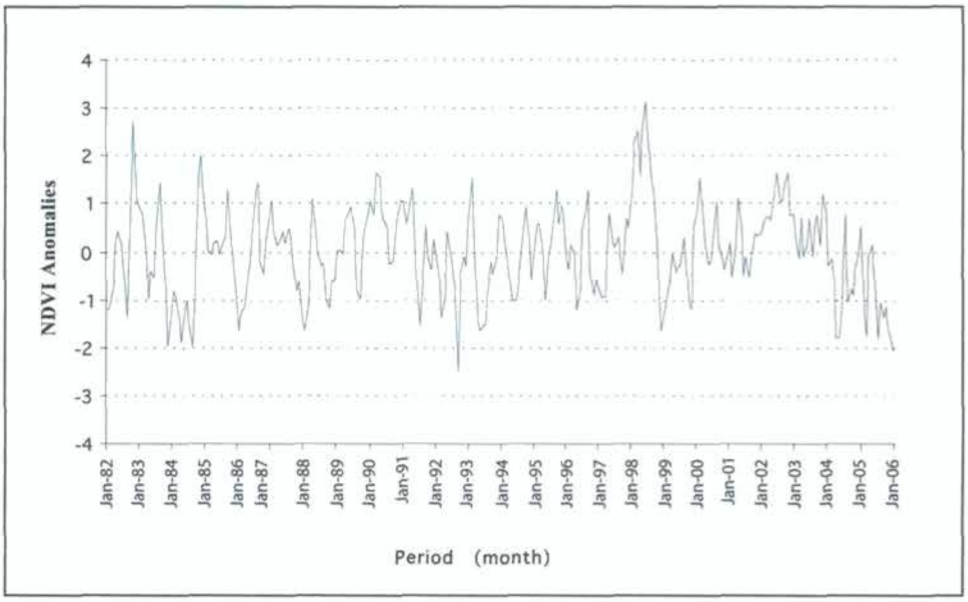


Fig. iv. Monthly NDVI anomalies between 1982 and 2006 for Kitui and Mwingi Districts

E. Garissa District

11. Garissa was among the hardest hit districts by the 2005/06 drought. NDVI anomalies for that period reveal that the recent drought was more severe than the 1999/2000 drought (figure v). Heavy losses of livestock and acute shortages of food, pasture and water were reported in the region. Anomalies show that the district had experienced prolonged droughts since 2004 hence exacerbating the impacts of the 2005/06 drought in the District.

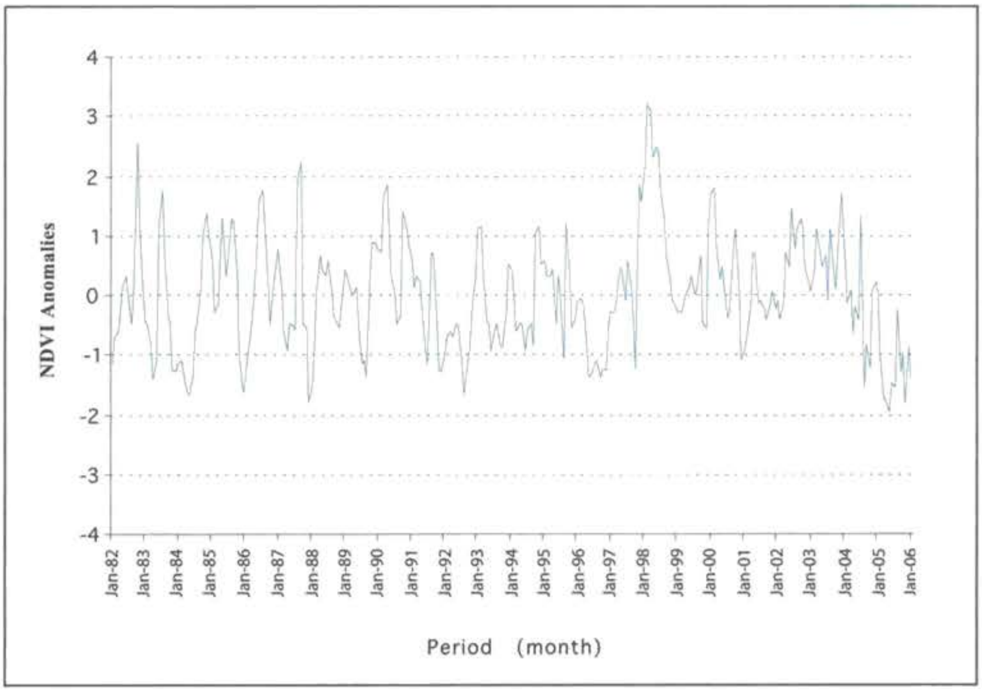


Fig. v. Monthly NDVI anomalies between 1982 and 2006 for Garissa District

F. Wajir District

12. This district was also heavily impacted by the 2005/06 drought. The NDVI analysis reveals that the current drought was worse than the 1999/2000 drought (figure vi). There were reports of acute shortages of food, water and pasture in the district, resulting in immense suffering to the residents.

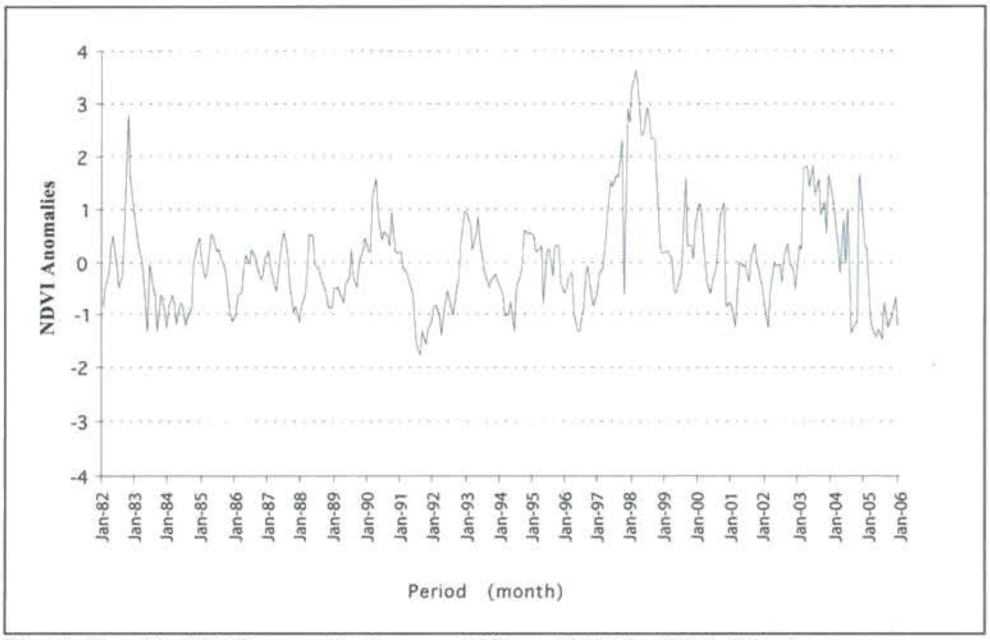


Fig. vi. Monthly NDVI anomalies between 1982 and 2006 for Wajir District

G. Narok District

13. Narok is located in the southern rangelands. The NDVI analysis reveals that the drought of 2005/06 was less severe in the district than that of the year 1999-2000 (figure vii).

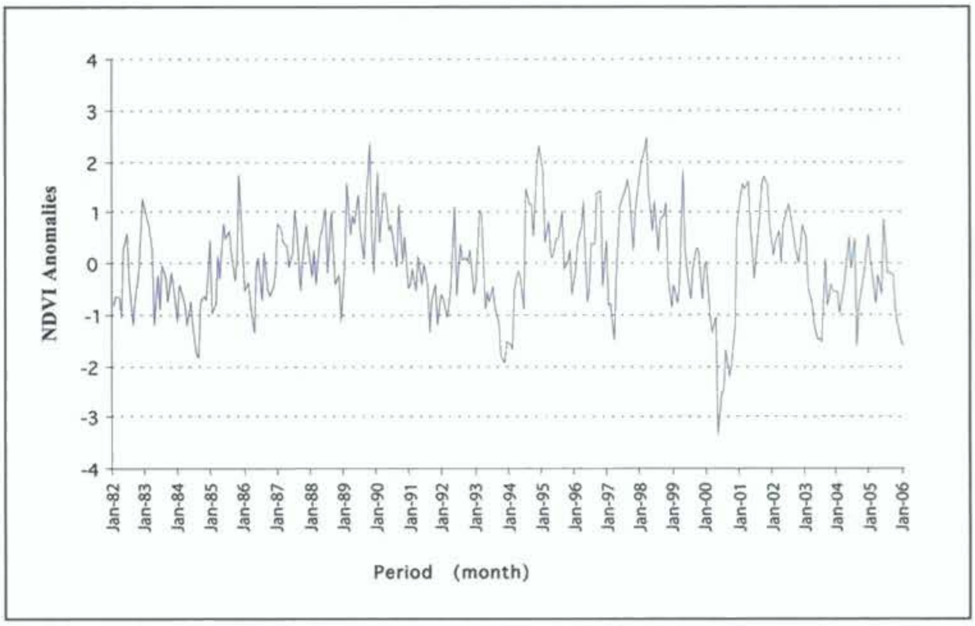


Fig. vii. Monthly NDVI anomalies between 1982 and 2006 for Narok District

H. Turkana District

14. Located in the Rift valley, Turkana District is periodically affected by persistent dry spells. However, the analysis of NDVI shows that the 2005/06 drought was mild compared to the 1999/2000 drought, with the district receiving fair rains in 2005, resulting in favourable vegetation conditions (figure viii).

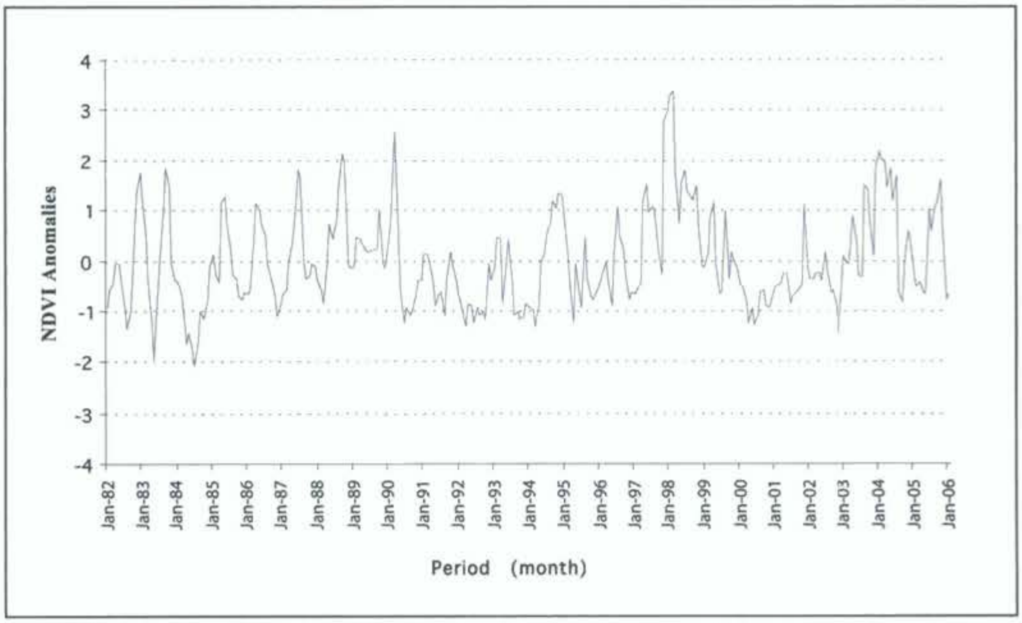


Fig. viii. Monthly NDVI anomalies from 1982 to 2006 for Turkana District

III. Wildlife and Livestock

15. Over 40 percent of Kenya's cattle and approximately 20 percent of its sheep and goats were lost during the 2005/2006 drought, according to the Arid Lands Resource Management Project (ALRMP, 2006). In some areas, people trekked up to 50 km to reach watering points. The distance between pasture and water is critical in the pastoral food production system. Usually, even after reaching a watering point, livestock could not access water for more than two days because of the increased pressure on the wells. Pastoralists were forced to move their dying animals into the verges of the capital Nairobi, as the search for vegetation continued. Alternatively, they had to sell livestock for the price below market value, about US$3-5.

16. The loss of livelihoods for pastoralists was particularly detrimental as it occurred for the most part in Kenya's Northeastern least developed districts. The pastoralist populations of these districts have little or no access to health infrastructures. If the next rains fail, the entire livestock population of Wajir will be lost, destroying the main livelihood of the majority of the district's citizens. These people will become entirely dependent on relief aid.

IV. Water Resources

17. Poor rainfall in the short rain season of October to December 2005 exacerbated water shortages in not only drought-affected Eastern and Northern pastoral districts and the South-eastern lowland cropping areas, but also in areas regarded as of high potential in Kenya. USAID Famine Early Warning Systems Network (FEWS NET) reported significant livestock deaths and reduced productivity due to lack of water and pasture, leading to little or no milk availability. As a result, rates of child malnutrition increased dramatically in parts of the most-affected districts of Wajir, Mandera and Marsabit, with global acute malnutrition (GAM) rates ranging from 18 to 30 percent. In February 2006, FEWS NET estimated that more than 3 million people were facing extreme food insecurity and required food assistance through February 2007. The drought disrupted the social setup of people, and in extreme cases, migration to other areas occurred. The Samburu pastoral community for example moved all the way to the Mount Kenya forest in search of pasture and water, which at times resulted in hostility from the local farming community.

18. The drought and subsequent competition for pastures and water drove animals out of pasture lands in search of water and food, often near human settlements. Animals were forced to migrate out of national parks such as Amboseli and reserves such as the Maasai Mara and into surrounding populated neighborhoods, triggering conflicts between wildlife and people (SFS Center for Wildlife Management Studies (CWMS). The African Wildlife Foundation states the rehabilitation of water sources as its primary recommendation for the mitigation and reduction in this shared conflict for water (AWF 2000). Restoring water sources would encourage animals to utilize less populated, pastoral areas away from agricultural land and reduce current conflicts over water sources (Centre for Wildlife Management Studies, January 26, 2006).

V. Drought Impacts on Water Resources

19. Water is an important resource to all sectors in Kenya i.e. from domestic to industrial. The source of recharge for both surface and ground water is precipitation consisting of the long (March-May) and short (October-December) rains, a cycle that was not consistent in the drought year (2005 to early 2006). This resulted in a serious drought that has been

described as among the most severe to ever hit the horn region. The poor rains led to very serious water shortages that caused the death of more than 70% of the pastoral livestock. This drought underscores the fact that water is still a limited resource in Kenya that requires good management to be sustainable. Specifically, it continues to unearth several underlying weaknesses in Kenya's water sector.

20. The drought was observed to have resulted in reduced water volumes in the various reservoirs and ground water table levels. Further, the drought exposed an imbalanced distribution of water within the country, which led to human and animal migration and an increased competition for water. The volume of water in rivers and other reservoirs decreased significantly with most districts registering deficits. This impacted on both rural and urban areas. Water supply in the capital, Nairobi, was rationed as a result of low dam levels at Ndaka-ini and others reservoirs. Collection pans and streams also dried up, leading to severe shortages and low recharge of underground reserves. In order to render this situation, the government transported water to the most affected areas at a high cost. Economic resources allocated to various projects in some Ministries had to be deviated to address this problem.

21. The volume of water in hydroelectric generating plants also decreased drastically, requiring the main power generating company KENGEN to contract diesel powered generating companies to bridge the gap. This helped avoid electricity rationing and perhaps indicated improved management from lessons learnt in the previous droughts. However, the low generation capacity resulted in far reaching consequences on the country's economy due to increased electric cost on production for companies.

22. Though essentially a social factor, there were economic implications of the supply and demand of water among the urban dwellers. For instance, private vendors took advantage of the desperate town dwellers to raise the cost of the water by as much as 400% dependent on the demand.

23. The drought also severely affected the rural areas, where people mainly rely on streams and dams, which generally dried up. This had far reaching impacts on the rural populace in terms of demographics, water quality and distances travelled in search of water. There was also an economic implication among the rural population where, in extreme cases, people had to buy water at exorbitant prices. Competition for the few remaining water sources led to conflicts as was reported in many parts of Northeastern and Upper Eastern provinces. The prolonged drought also intensified the conflict in Naivasha between farmers and pastoralists.

24. The slow decrease in river levels over the years and increased soil erosion could also have compounded water crisis significantly. This is a result of poor environmental management over the years due to excessive exploitation and has been attributed to economic marginalization and lack of poverty alleviation programmes, driving poor communities to encroach into the catchment (Nation, April 5, 2004). Inadequate water storage capacity in the form of pans, dams, underground storage dams and even industrial tanks could also have added to the general shortage. There is an increased level of activity to try and address the water shortage in the marginal lands with the digging of more boreholes by the government.

25. On the other hand, economic effects of the drought underscore the inter-relationship between the various sectors and their dependence on adequate water supplies. The lower

numbers of power outages may indicate the adoption of lessons learnt from previous drought experiences, indicating improved preparedness and mitigation capacity.

VI. Conclusion and Recommendations

In conclusion, NDVI anomalies corroborated the severity of the 1999/2000 and 2005/2006 droughts in all the Districts included in this report. NDVI anomalies were larger during the period 1999/2000 than during the 2005/2006 drought in Kajiado, Narok and Turkana Districts indicating a significant loss of vegetation mass due to precipitation deficits. In particular the Narok District was the most severely impacted by the 1999/2000 drought when NDVI anomalies were lower than -3.0 High negative anomalies indicate less than normal vegetation productivity for those time periods. In the Districts of Turkana and Narok the recent drought has had a milder impact than the drought experience in 1999/2000 whereas Kwale and Isiolo Districts, had no significant differences. In Kitui, Mwingi, Garissa and Wajir Districts the recent drought had a more severe impact than the 1999/2000 drought.

26. The long and short term answer to the problem is a combination of food and non-food aid in the form of funds for water, sanitation, and pastoralist programmes such as de-stocking and re-stocking of cattle, and education. The number of people affected by drought will reduce drastically if the government takes care of the non-food sector.

27. The revival of Kenya Meat Commission (KMC) will soon play an important role in the response to drought, especially in buying-up of stock during normal periods and subsequently selling the meat products as canned goods during food crisis.

28. Concerted efforts to preserve the little water available and at the same time develop alternative sources for water, especially for the pastoral communities, are recommended. The enactment of the National Water Conservation and Pipeline Corporation (NWCPC) in 1988 to improve water supplies, among other things, seems to have had little effect as continued impacts of drought are apparent. Reported impacts of the drought also showed a residual gap in storage that aggravated the problem and brings attention to the lack of government effort to educate its people on the need to conserve water.

Executive Summary

Introduction

Kenya was hit by a series of droughts in 1991-92, 1996-97 and 1999-2000, and a devastating flood in 1997-98. The 1999-2000 drought occurred against a background of long-term economic recession, where water and food requirements, and security affected almost every sector. The drought and events that followed will be remembered as probably one of the worst disasters experienced in the country in over 40 years. Failure of the long rains in March 2000 was the fifth successive dry spell over a period of two years. Consequently, the soils were left with severely inadequate moisture to sustain plant growth and resulted in the destruction of crop fields, water resources, vegetation cover, severe environmental degradation and ultimately the loss of ecosystem goods and services.

The arid and semi-arid lands (ASAL) were worst hit by this drought due to the fragile nature of this ecosystem, breakdown of traditional drought coping mechanisms and rapidly changing land use. The loss of livelihoods brought incalculable suffering to over 40 millions of people in more than 22 districts. Millions of people starved and struggled to restore their homes and regain livelihoods.

Remarkable losses occurred in the livestock numbers as their conditions deteriorated rapidly and pastoralists reported a huge loss, mainly of cattle as well as camels, sheep and goats. Numerous animal carcasses were widely observed strewn in most districts majority of which belonged to cattle. This serves as clear evidence of starvation related mortality although diseases may have taken a toll on weakened animals. The products of emaciated animals recorded the lowest market prices and were a further loss to the pastoralists. Another consequence of the severe droughts is the occurrence of rampant animal movements within Kenya in search of pasture and water. As a result, large concentrations of livestock were reported around the remaining water points and other locations including the Mt. Kenya region and even within the residential areas of Nairobi city. Ultimately, the scarcity of water led to high concentrations of people and other animals in limited, patchy habitats, which culminated in conflicts of resource use and further degradation of the environment.

In response to the high crop failure, which prompted an appeal from the World Food Programme for US$88 million to feed nearly 3.3 million Kenyans in need of food relief, the Kenyan Government declared it a national disaster. The WFP spent US$102 million on food relief alone while the Government spent more than Ksh 10.5 billion on emergency relief food during the 2000/2001 financial years. Total damages are believed to have cost at least Ksh 220 billion, more than triple the damages to Kenya caused by the 1997 El Niño floods, which cost approximately Ksh 70 billion.

Key findings

This report is the product of a collaboration between the UNEP Division of Environmental Policy and Implementation (DEPI) and the Department of Resource Surveys and Remote Sensing (DRSRS) in the Ministry of Environment and Natural Resources. Providing an assessment of the impact of the drought of 2000 on livestock and wildlife populations, this report focuses on selected districts within two savannah ecosystems in Kenya, including the southern rangelands (Kajiado, Narok, and Transmara districts) and the northern rangelands (Laikipia, Isiolo and Samburu districts). This report also provides a comparative analysis of the historical trend of droughts in the arid and semi-arid region, represented by the above-mentioned districts, and the high potential areas, represented by the districts of Nakuru and Murang'a. Further discussion is given to the impact of drought on food production, water resources and catchments, and economic development. Finally, this report examines the trends of human population growth and agricultural encroachments into marginal areas, and deforestation as some of the factors responsible for land degradation and enhancement of drought severity.

In Kenya, droughts occur in a cyclic pattern. The vegetation indices (VI) data from NOAA AVHRR satellite provide the spatial distribution of drought conditions, intensities and duration in different ecological regions. From this data, a cyclic pattern of drought episodes with return periods of 6-10 years emerges in most districts. In the recent years, critical drought periods throughout the country were experienced in 1984, 1994 and 2000. In the case of Kajiado district, for example, major droughts occurred in 1982-1984 and 1999-2000, while other, less severe ones were recorded in 1992, 1994, 1996 and 1997. While the local people interviewed in the district perceive the 1984 drought as the worst one of the last two decades that of the year 2000 appears to be the most severe. This was partly because the latter drought persisted over a long period with no time for recovery. In the neighbouring districts, including Trans Mara and Narok, the drought pattern closely followed that of Kajiado, but in less intensity and severity. These districts occur along a rainfall gradient with the former and northern part of Narok district lying within the highlands and are the wettest, while Kajiado is always the driest.

Similarly, Laikipia, Samburu and Isiolo districts lie along a rainfall gradient where Laikipia is always the wettest and Isiolo is the driest. Laikipia district experienced droughts in the years 1983-84, 1986, 1991-92, 1994 and 2000. The drought pattern in Isiolo district indicated the worst period as in 1991-92, but other severe episodes were recorded in 1993, 1994, 1996, 1997 and 2000. These being major livestock production and wildlife areas, both the pastoralists and wildlife populations faced significant losses.

Notable drought episodes have also been recorded in the high potential districts of Nakuru and Murang'a. The agricultural district of Nakuru experienced severe droughts in 1984, 1991-92, 1993-94, and the worst in the year 2000, which was especially detrimental to crops. Murang'a district had a prolonged drought in 1983-85, minor ones in 1986, 1992 and 1996, and the worst in the year 2000. In the latter period, rampant land degradation occasioned by increased poverty levels and the breakdown of cash crop farming such as coffee led to the lack of sustainable income and aggravated the impacts of the drought.

Intrinsically linked factors aggravated drought impacts. There are several factors that aggravated the severity of the drought impacts in many areas. Change in land use activities is the single most important factor that is responsible for severe land degradation. In recent years, encroachments by agriculture, especially large mechanized farms and the sub-division of large communal lands into small individual parcels in the arid and semi-arid areas, has led to rampant removal of vegetation cover, exposing the soils to infertility, erosion and a drop in water-holding capacity. The conversion of fragile ecosystems into cultivation land has interfered with the natural balance of the systems, while loss of habitats has deprived the pastoralists, their livestock and wildlife of important dry season grazing and dispersal areas.

Rampant movement of the pastoralists with their livestock both from within and outside the districts in search of pasture and water was partly responsible for the severity of drought. Concentrations of large population of people and animals in patchy habitats rapidly diminished the meager resources, increased competition and led to further land degradation and conflicts. In most cases, the nature of conflicts in resource use especially for water and grazing areas degenerated into clan or tribal clashes with massive loss of life in a few isolated instances. Such incidences were reported mainly in Garissa, Ijara, Tana-River, Mandera, Isiolo, Samburu, Laikipia, Narok, Pokot and Baringo districts among others.

People's livelihoods were heavily impacted. A majority of the victims of the drought in 2000 were the rural poor people who depend on ecosystem services and natural resources for their livelihoods. These sources of income and food were unsustainably used prior to the drought and led to increased losses, suggesting the urgent need to find sustainable alternatives. Almost all the sectors were affected, but the most severely impacted were water resources, agriculture, livestock production and industrial. As Kenya is an agricultural based country, many victims were involved in crop cultivation, agro-pastoral activities and pastoralists' livestock keeping. Particular attention needs to be paid to sustainable land use activities including improved crop cultivation, dryland farming, livestock management and range utilization. The sustainable balance between the rangelands and livestock production in the ASAL must be re-established, small-scale agro-pastorals and mechanized commercial farmers who hire large tracks of land and abandon them for more fertile areas need to be assisted to use suitable land use methods.

High crop failure resulted in high decline of food production. Food production has steadily declined over the years. However, the high crop failure during the 2000 drought prompted the World Food Programme (WFP) to appeal for US$88 million to feed almost 3.3 million Kenyans in need of food relief. A comparison of natural disasters clearly reflects the severity of the effects of the drought in 2000. The El Niño of 1997 led to over a 23,000 ha increase in the area under the maize crop in the Narok district while the drought of 2000 led to the lowest crop yield since 1995 (a drop from 3 tons/ha to 0.5 tons/ha). Although grazing by livestock and wildlife certainly played a role in damaging crops, this drastic reduction of maize yield is primarily attributed to the drought. In many places, the maize deficit was partly supplemented by the huge donor assistance in form of relief food aid. Similar damages occurred to wheat production as the area under wheat was increased significantly in anticipating rains, but rather declined to its lowest (< 10 tons/ha). In most parts of the country, all the crops wilted and dried out, leaving bare ground exposed to soil erosion.

Pastoralists' livestock was tremendously reduced. Large numbers of the livestock, irrespective of their range, was severely affected by the 2000 drought. A majority of the animal mortality was due to starvation. Grazers, mainly cattle were the most affected, but camels, sheep and goats, which are either browsers or mixed feeders also suffered. In the case of Kajiado district, the pastoralists lost more than 50% of the cattle and only 20% of sheep and goats. Some individual pastoralists lost their entire herds. The remaining animals were severely emaciated and the price of their meat or hides and skins declined drastically.

A total of 3,980 animal carcasses were counted in Laikipia district, almost 5,380 in Samburu district and 13,540 in Isiolo district. Laikipia depicted a lower animal carcass ratio (0.9%) as compared to Samburu (1.2%) and Isiolo (3.1%) as the three districts are arrayed a long a rainfall gradient with the former always the wettest and the latter the driest. Almost 3,530 carcasses were sighted in Narok and Trans-Mara representing 0.25% of total large herbivores in the two districts. About 5,760 carcasses were also observed in Kajiado, which represented almost 0.67% of large herbivores in the district. Other un-surveyed districts also contributed a large number of dead animals and huge setback to the national economy. The recovery process was slow especially among the poor rural communities. The affected pastoralists needed assistance in restocking their lost herds. In the absence of such assistance, they might turn to stock thefts and raids among different clans or the neighbouring communities.

Wildlife was also affected. Among the wildlife species, the drought resistant species including Grant's gazelle, gerenuk, giraffe, kudu, and Grevy's Zebra were less affected. However, the dependent species and mainly the grazers such as Burchell's zebra, buffalo and wildebeests were severely affected. Most of the animals migrated out of their range and dispersed widely, making them susceptible to poaching. A few wildlife carcasses were observed within the protected areas, as was the case in the Maasai Mara game reserve.

Excessive demands placed on institutional capacity. The 2000 drought was declared a national disaster by the Kenya government. However, the capacity of the already burdened environmental agencies was severely overstretched by added responsibilities of relief, recovery planning and assessments. In response to the Government appeal, the World Food Programme (WFP) spent almost US$ 102 million on food relief alone. In addition, WFP required more than 15,000 tons of fortified blended foods for supplementary feeding programmes in 11 of the most affected districts in the marginal areas of Rift Valley, North Eastern, Eastern and Coast provinces. The Government spent more than Ksh 10.5 billion on emergency relief food during the 2000/2001 financial years. The 1999-2001 La Niña drought cost the country at least Ksh 220 billion as compared to the 1997 El Niño floods that cost approximately Ksh 70 billion.

Drought monitoring and early warnings are important aspects of drought management and food security. The government through the Arid Lands Resource Management Project (ALRMP) had an early warning programme that covered 10 marginalized districts. The programme targeted households and communities using local recruits to gather information on rural economic and environmental indicators. This was an important initiative towards the management of drought impacts, however, the programme was still in its formative stage in 2000. Although the country had the necessary institutional infrastructure to help mitigate drought impacts, many environmental agencies and NGOs lacked facilities and equipment. In addition, they were poorly coordinated and had inadequate capacity to manage disasters in the affected areas, covering, for example, integrated arid land management, strategic environmental assessment, and integrated economic and environmental planning.

Deteriorated water catchments. In the recent past, widespread deforestation occurred in the key national water catchment's areas. Between 2000 and 2003, the major water catchments of Mt. Kenya forest, Mau forest, Mt. Elgon forest and Cherangani forest were deforested by 2.2%, 2%, 1.8% and 0.2% respectively. These forests, together with the Aberdares, constitute 91% of the total water catchments protection forest value in the country. The breakdown of livelihood during the drought period brought the communities living adjacent to forests to this resource for survival purposes.

Severe water shortage affected other sectors of the economy. Almost 70% of the country's power supply is obtained from hydroelectricity. At the peak of the year 2000 drought, the capacity of hydroelectric power generation went down tremendously and resulted in the closure of some of the main hydro dams. Power rationing was frequent and at times lasted over weeks, negatively impacting the manufacturing industry and domestic welfare. In total, the government revenue loss was estimated at $2 million per day.

In the urban areas, water vendors hiked the cost of water by almost 400%, which affected the low-income members of society who had no piped services as well as those in the well-serviced areas where pipes had gone dry. As water became scarce, tension and conflicts among various water users increased. Inadequate rainwater harvesting techniques and storage capacities in the form of pans, dams, and tanks highly contributed to the general water shortage.

Recommendations

After a drought, the restoration of destroyed livelihoods that depend on the damaged environment is a demanding task. Addressing the mainstream environmental concerns is prerequisite to ensuring sustainable reconstruction. In the case of the year 2000 drought, effective drought management requires a more concerted effort to put in place coherent mechanisms by all the players involved in monitoring and mitigation. Rehabilitation and reconstruction of the environment should be an effort that is people-centered, gender sensitive and participatory in nature. The recovery process is often especially slow among the poor rural communities, which are at a great disadvantage when it comes to adapting to change in physical environment and habitats.

Major projects such as reforestation of water catchments and denuded areas, improved water harvesting, upgrade of livestock farming, sustainable drylands farming and range management are needed in all affected areas to restore ecosystem goods and services. A successful effort will likely require international support and will certainly need to include capacity building in techniques for rapid assessment and rehabilitation urgently.

Detailed environmental assessments including vulnerability mapping will provide critical inputs for drought management and mitigation. The following gaps were identified based on rapid assessment and field interviews with the affected communities:

i. Inadequate environmental guidelines in natural disaster plans and land use policy for sustainable and management of resources;
ii. Lack of comprehensive resource surveys, vulnerability mapping and risk assessment;
iii. Inadequate coordination between the relief agencies and participating NGOs in disaster management;

In integrated assessment, information is collected from various stakeholders making it essential to harmonise assessment procedures in order to limit biases.

Adequate land-use policy put in place. The government should urgently address the need for land use policy to guide the planning, utilization and management of land resources especially in the fragile ecosystems. This action should include strategic environmental assessment on major land use changes and the destruction of ecosystems that were traditionally used in drought coping mechanisms. The areas of concern are communal lands and pristine habitats formerly used for livestock and wildlife dry season grazing that have since been encroached into and converted to agricultural land, the destruction of water catchments and upstream dams for horticultural activities, introduction of large mechanized farms including wheat farming in the ASAL areas, overstocking of livestock, and overgrazing.

In the arid and semi-arid lands, small individual parcels of land are not viable for agro-pastoral activities due to the harsh climatic conditions. Rather, the consolidation of these land units into large communal or group ranching enterprises offers a better option than the smaller land units. The success of wildlife survival and livestock management on the large ranching enterprises in Laikipia district exemplify the benefits of this alternative for agro-pastoral activities. It is recommended that the pastoralists land tenure system be incorporated into similar land use plans in these areas.

Detailed studies on the relationships of factors responsible for drought severity including demographic, land use activities, water balance, land degradation and socio-economics are needed. This information will guide appropriate policy formulation in the management of drought.

Conservation of water catchments, environmental awareness and community participation will improve preparedness and sustainable resource management. The importance of watershed conservation, water resource management and implications associated with land degradation, loss of vegetation cover, alteration of hydrology and water quality cannot be overemphasized. A rural participatory and sensitization approach will encourage resource ownership and maximize the economic and social welfare benefits without compromising sustainability in resource utilization.

Rainwater harvesting strategies including those for domestic water use and agricultural activities need to be established. Affordable technology should be made easily accessible and its use encouraged. Increased damming of rivers where environmental impact assessments have been taken into consideration is also recommended. Damming will provide long-term sources of water for use not only for domestic purposes but also for other economic benefits including hydroelectric power production and irrigation schemes. Furthermore, the rural livelihoods will be improved by the creation of employment opportunities. Ultimately, both the public and private sectors must invest in water resources to avoid future water shortages as this has rippling effects in all sectors.

Environmental awareness and community participation will improve conservation activities and sustainable resource management. Basic education and environmental awareness could make a huge difference in preparedness. The public needs to be aware of climatic change indicators and mitigation measures. It is often said that indigenous people, who are considered closer to their natural environment, maintained and shared this knowledge through their folklore. The same awareness needs to be built into the school curriculum and mass media (radio, TV and daily newspapers). The apparent sensitivity of certain animals to migrate during the dry periods or to breeds as the wet seasons approaches suggests that animal behavior should also be studied and documented.

Community participation should also be used to manage catchments and to rehabilitate the degraded areas. Awareness programmes should therefore include sensitization on proper land use practices and conservation of forests. It is necessary to clearly explain the direct link between sustainable forestry and the recharge of water resources.

Women, being the most affected by water shortages, should be fully involved in management schemes. Their involvement will lead to sustainability and development since improving access for them will lighten their burden and allow for their participation in other areas of the economy.

Public awareness campaigns on the need to use water efficiently by avoiding wasteful use and on other water saving technologies should be carried out through the newly established Water Management Authority. This will not only help in revenue savings but also guarantee supply in the time of scarcity.

Long-term sustainability:

Better land use planning and management in ASAL will reduce vulnerability and environmental stress. The arid and semi-arid zones will remain vulnerable areas to drought due to the low and unreliable rainfall experienced, making such ecosystems very fragile. Proper land use planning backed-up by adequate land use policy and community-based integrated arid lands management must be fundamental principles in the mitigation of drought impacts.

Environmental Impact Assessments are critical. Environmental Impact Assessment (EIA) of projects and strategic environmental assessment (SEA) of overall plans and programmes in drought-vulnerable areas must be undertaken. Potential threats to natural ecosystems arise from such activities as the increased sub-division of large pastoral lands in the ASAL into small individual parcels based on agro-pastoral activities and from encroachment by large commercial wheat farming. For example, in Narok district this encroachment has deprived the Maasai pastoralists and wildlife of an important dry season grazing area, negatively impacting livestock production and eco-tourism in general.

Early warning systems must be put in place and the capacity of environmental institutions strengthened. There was considerable concern that much loss of life, livestock and crops could have been avoided if there had been an adequate early warning system in place, identifying an improved system as a priority. It is therefore essential to consider the multi-hazards warning system, as well as the network of regional and national early warning systems proposed under the Global Earth Observation Systems. The development of these systems must be well rooted at the national and local institutions in order to be effective. The Arid Lands Resource Management Programme (ALRMP) has an early warning programme in 10 arid and semi-arid districts based on rural economy, human welfare and the environment as indicators. This programme must be fully supported as it targets households and communities.

Ongoing efforts by the government and concerned organizations to address urgent environmental challenges posed by the drought demonstrate their strong commitment to sound environmental management. This spirit should be joined and fully supported by the international community. With continued cooperation between national and international actors, the country can establish a course towards drought mitigation and recovery, protection of its natural heritage, and restoration of livelihoods.

Institutions dealing with resource survey and assessment, environmental disaster management and early warning often need direct technical assistance. Such institutions include: The Kenya Meteorological Department (KMD), which provides daily weather forecasts, seasonal weather outlooks and the distribution of rainfall anomalies maps; the Ministry of Agriculture (MoA), which provides bulletins on crop distribution and performance; and the Department of Resource Surveys and Remote Sensing (DRSRS), which uses remote sensing techniques for rapid assessment and monitoring of natural resources status and environmental conditions. It is important to stress, however, that the provision of technical assistance should be combined with capacity building in priority areas. In addition, the linkage between early warning, crop forecasting and food security institutions, and drought mitigation programmes run by the government and NGO's, including the WFP, should be strengthened.

Pastoralists' livestock management strategies played a greater role in sustaining livelihoods during the drought. The system is complex, involving the wide-ranging movement of people and livestock in search for greener pasture and the splitting of animal herds into smaller groups. It also involves the switching of livestock in different seasons. For example, pastoralists keep smaller stocks such as sheep and goats during the dry spells and turn to cattle at the onset of the rains. In the presence of an adequate early warning system, the pastoralists will be advised in time to sell their large stocks when the prices are good and before the drought commences. This will ensure both economic stability and restocking as the dry spell ceases.

INTRODUCTION

Kenya experienced a devastating drought between 1999-2000, which resulted from the failure of four consecutive rainy seasons. This drought caused widespread disruption of livelihoods, especially in the arid and semi-arid zones, but also in the high potential areas that are often not much affected by dry spells. The pastoralists migrated in large numbers together with their livestock in search of pasture and water. The random movement of people and animals escalated at the height of the drought and resulted in conflicts by competing for the limited resources. High migration of human beings from the rural areas to urban centers in search of employment to sustain their families was also noted. A joint collaboration effort of the United Nations Environment Programme (UNEP) and the Government of Kenya conducted a rapid qualitative assessment of the impacts of this drought on the environment. Results showed that (i) the impacts of the year 2000 drought was worsened by the effects of the 1997-98 El Niño rains, which had reduced the water holding capacity and; (ii) the drought adversely affected nearly all the sectors including livestock and wildlife, biodiversity, agriculture and water resources, industry, social and economic welfare; and (iii) there was general lack of relevant data and information on the status of natural resources, land use activities and previous droughts.

The team recommended that the impacts of the year 2000 drought on the vegetation, land use, wildlife and livestock should be studied in detail to provide baseline data for future planning and monitoring. The Department of Resource Surveys and Remote Sensing (DRSRS) was mandated to carry out this exercise with specific tasks to: acquire satellite images for the year 2000 to assess the change in vegetation cover at the height of the drought; analyze the Normalized Difference Vegetation Indices (NDVI) data between 1982 and 2004 to assess the trends of the droughts; conduct aerial surveys in pilot districts to assess the drought impacts livestock, wildlife and human settlements; integrate using Geographic Information Systems (GIS) the information acquired above and incorporating other related environmental parameters to analyze and derive the impacts of the drought.

Scientific and quantitative data on environmental parameters useful for resource monitoring, planning and management, and decision-making was generated in this exercise. Specific area assessments of the vegetation cover and food production were also undertaken. The severity of the year 2000 drought was aggravated by a number of factors including influx of human population coupled with agricultural activities into the rangelands, depletion of resource base, land use changes and environmental degradation among others. The information gathered was geared towards drought mitigation and management in the country.

CHAPTER 1

IMPACT OF DROUGHT ON LIVESTOCK AND WILDLIFE POPULATIONS IN TWO SAVANNAH ECOSYSTEMS OF KENYA

1.0 Introduction

Drought episodes are known to recur in Kenya over a cyclic pattern. Drought incidences associated with famine were recorded in the country between 1960-61, 1970-71, 1983-84, 1991-92 and 1999-2000. Over these years, the 2000 drought was probably one of the worst experienced. Failure of the long rains in March 2000 was the fifth successive dry spells over a period of two years. Consequently, the soils were left with severely inadequate moisture to sustain plant growth. The semi-arid and arid lands were the most affected and suffered massive loss of vegetation cover and severe land degradation. Over 4 million people in more than 22 districts suffered from the impacts of this drought. Severe dehydration and lack of forage led to the death of a large number of livestock and wildlife.

The status of livestock and wildlife in the year 2000 was assessed in six representative districts of two savannah ecosystems to determine the impacts of the drought on their populations. The districts covered were Laikipia, Isiolo and Samburu in northern Kenya and Narok, Trans-mara and Kajiado in the south. There was a rapid decline in the population of most animals, especially the grazers. Remarkable dispersal of species in relation to plant biomass availability was also noted. The drought had triggered extensive movement of pastoralists with their livestock and migration of wildlife along rainfall gradients. The rampant movement of people, livestock and wildlife resulted in large concentration of animals into patchy habitats. This had resulted into stringent resource use pressure, conflicts and further environmental degradation. Wildlife too migrated and the result was large concentrations of animals and people into restricted habitats, resource use conflicts and environmental degradation. The inter-ethnic clashes during this period were mainly attributed to competition over scarce resources especially for pasture and water.

In adequate preparedness and lack of mitigation measures, local capacities and coping mechanisms for drought management increased the vulnerability of people, livestock, wildlife and environment. The other factor that aggravated the impacts of the droughts was the influx of people into the semi-arid and arid lands, and subsequent introduction of agriculture and sedentary lifestyle. This has largely contributed to the drastic modification of the vegetation cover in the fragile ecosystems. The emergence of extensive farms in the ASALs has deprived the wildlife of an important dry season dispersal areas and migratory routes, while subdivisions of large communal lands into small parcels has led to habitat fragmentation and loss of ecological balance.

1.2 Methodology

a) Aerial Census of Livestock and Wildlife

Large herbivores (wildlife and livestock) were counted and other environmental parameters recorded in two savannah ecosystems at the peak of the year 2000 drought. The districts covered were Laikipia, Samburu and Isiolo that represented the northern rangelands, and Trans-mara, Narok and Kajiado representing the southern rangelands. Systematic reconnaissance flights (SRF) surveys already described by Norton-Griffith (1978) and adopted by the Department of Resource Surveys and Remote Sensing (DRSRS) was used. It involves counting of animals using light aircraft and based on sampling strategy. Animal carcasses were also recorded to assess losses due to starvation related mortality.

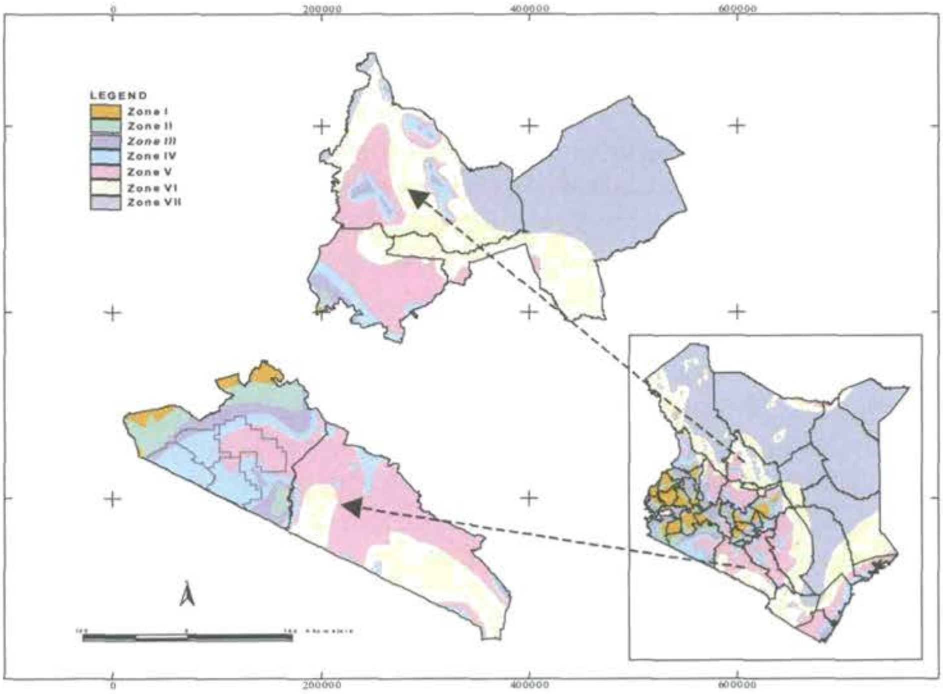


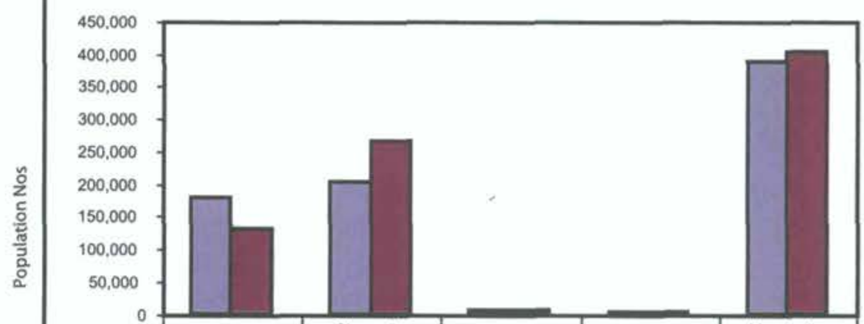
Figure 1.1. Location of Samburu, Isiolo, Laikipia districts in the north and Narok, Trans-mara and Kajiado in the south. In the background are the agro-ecological zones (I-humid, II-sub-humid, III-semi-humid, IV-semi-humid to semi-arid, V-semi-arid, VI-arid, and VII-very arid).

b) Data Analysis

The population estimates were calculated based on the Jolly (II) Method of unequal transects length (Jolly, 1969). The change in population between successive censuses was analyzed using the *'z-test'* (Norton-Griffith, 1978)

1.3 Case Study: Impact of 2000 Drought on Livestock and Wildlife in Northern Kenya

The northern savannah ecosystem was represented by three districts i.e. Laikipia district occupying approximately 9,666 km^2, Samburu (21,095 km^2) and Isiolo (25,322 km^2). All the districts in this region experience unpredictable rainfall most of the year and making them only suitable for pastoralism, ranching and wildlife use. For instance, Laikipia receives rainfall of 600-850mm/yr and Isiolo receives 100-580mm/yr. Other districts such as Turkana far in the north receives rainfall far much below. Overall livestock populations in Laikipia, Samburu and Isiolo districts had increased considerably between 1994 and 2001, but the wildlife had declined by



	Cattle	Sheep & Goats	Camel	Donkey	Livestock (totals)
1999	177,780	200,740	5,680	2,290	386,490
2001	130,020	265,520	4,250	3,080	402,870

Types of livestock

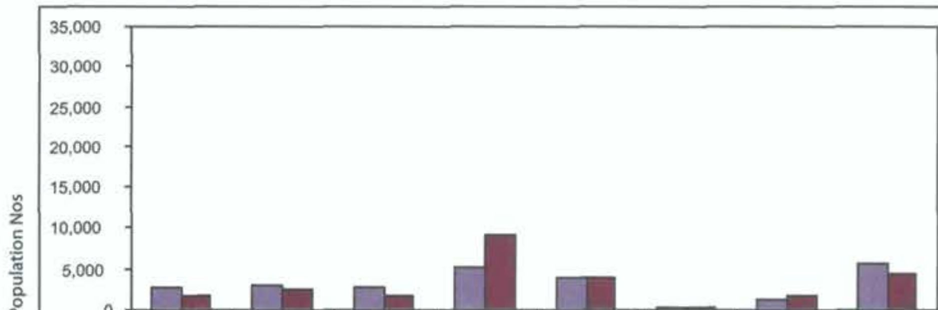
Figure 1.2 Livestock numbers in Laikipia district between 1999 and 2001

almost a similar proportion (Laikipia by 22%, Samburu by 27% and Isiolo by 24%). The increase of livestock was attributed mainly to the rampant movement of animals within and between the districts and migrations from outside areas including Marsabit, Wajir, Garissa, Turkana and Tana-River districts (Kufwafwa et al 1985, Wargute 1992).

a) Laikipia District

The livestock numbers in Laikipia had considerably increased from 386,490 animals in 1999 to 402,870 animals in 2001. The overall rise in livestock was attributed to the increased number of sheep and goats as well as donkeys, but cattle had declined drastically (Figure 1.2). Almost 3,980 animal carcasses were observed in the district at the peak of the drought, the majority of which belonged to cattle (Figure 1.9). Drought related animal mortality was lowest in the district as compared to the adjacent Samburu and Isiolo districts.

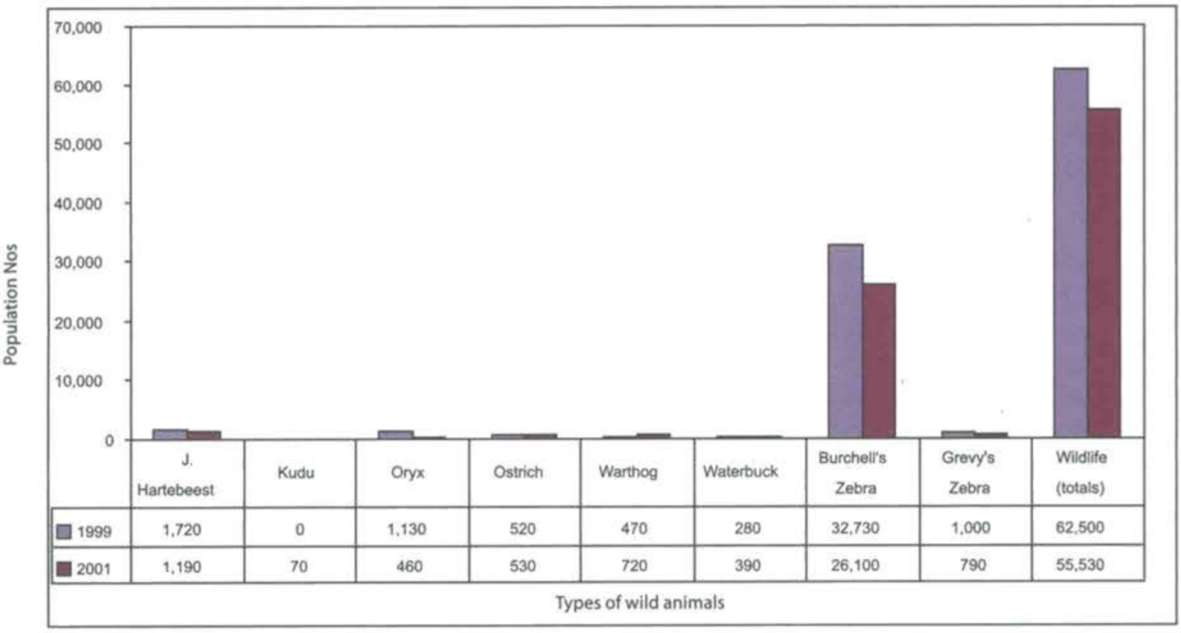
In 1999, the overall wildlife (large herbivore) numbers in the district were 62,500 animals. This number had reduced to 55,530 animals by the year 2001. Almost all the species declined in numbers. Among the species that had declined included the elephant, buffalo, hartebeest, eland, Burchell's zebra, Grevy's zebra, oryx and impala (Figure 1.3). However, the Grant's gazelle, gerenuk, giraffe, ostrich and warthog had increased over the same period.



	Buffalo	Eland	Elephant	Grant's Gazelle	Thom. Gazelle	Gerenuk	Giraffe (R)	Impala
1999	2,720	2,930	2,650	5,250	4,040	140	1,210	5,710
2001	1,670	2,420	1,750	9,070	4,040	220	1,720	4,390

Types of wild animals

Figure 1.3. Wildlife numbers in Laikipia district between 1999 and 2001

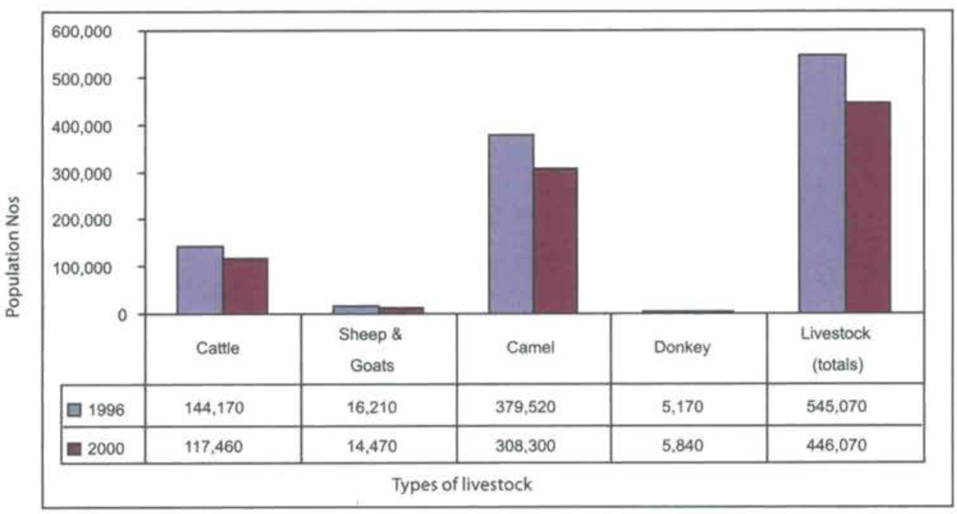


	J. Hartebeest	Kudu	Oryx	Ostrich	Warthog	Waterbuck	Burchell's Zebra	Grevy's Zebra	Wildlife (totals)
1999	1,720	0	1,130	520	470	280	32,730	1,000	62,500
2001	1,190	70	460	530	720	390	26,100	790	55,530

Figure 1.3 (Cont.)

b) Samburu District

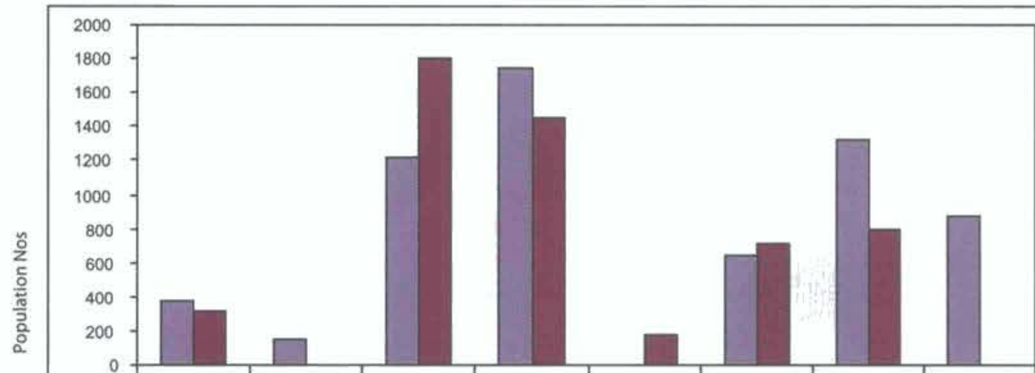
The overall livestock population in Samburu district was 545,070 animals in 1996 and 446,070 animals in 2000. This provided a decline of almost 18.2% in nearly four years (Figure 1.4). Cattle population had fell by 18.5%, sheep and goats by 10.7% and camel by 18.8%, but donkeys had increased by 12.9%. At the peak of year 2000 drought, almost 5,380 animal carcasses observed, of which the majority were of cattle (Figure 1.9).



	Cattle	Sheep & Goats	Camel	Donkey	Livestock (totals)
1996	144,170	16,210	379,520	5,170	545,070
2000	117,460	14,470	308,300	5,840	446,070

Figure 1.4 Livestock numbers in Samburu District between 1996 and 2000

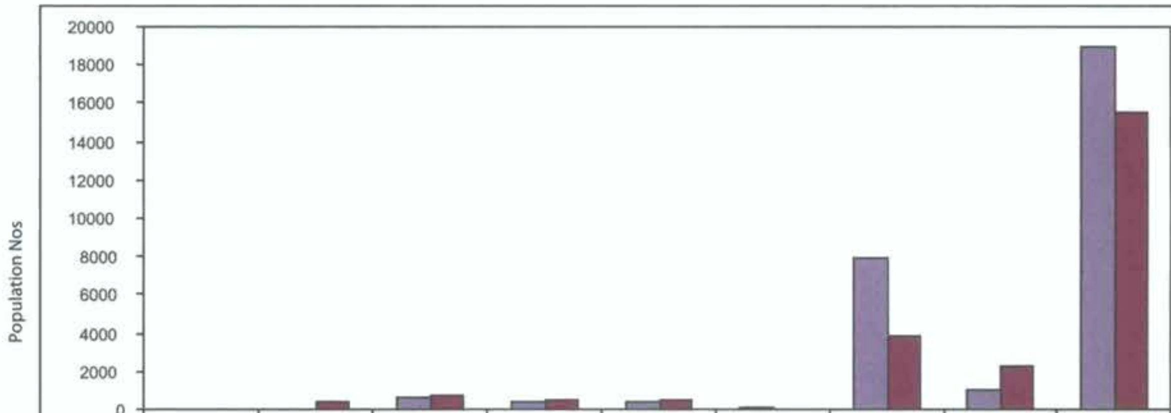
The overall wildlife (large herbivore) population was 18,976 animals in 1996 and 15,480 animals in 2000. Unlike the livestock species, most of the wildlife species had increased in the district, including elephant, Thomson's gazelle, gerenuk, kudu, oryx, ostrich, warthog and Grevy's zebra (Figure 1.5). Exceptions to this trend were the buffalo, Grant's gazelle, waterbuck and Burchell's zebra, whose numbers had declined.



	Buffalo	Eland	Elephant	Grant's Gazelle	Thom. Gazelle	Gerenuk	Giraffe (R)	Impala
1996	370	150	1,220	1,740	0	640	1,320	880
2000	310	0	1,800	1,450	170	710	800	0

Types of wild animals

Figure 1.5 Wildlife numbers in Samburu District between 1999 and 2000



	J. Hartebeest	Kudu	Oryx	Ostrich	Warthog	Waterbuck	Burchell's Zebra	Grevy's Zebra	Wildlife (totals)
1996	0	50	660	460	370	90	7,950	1,080	18,976
2000	0	380	690	480	500	40	3,850	2,300	15,480

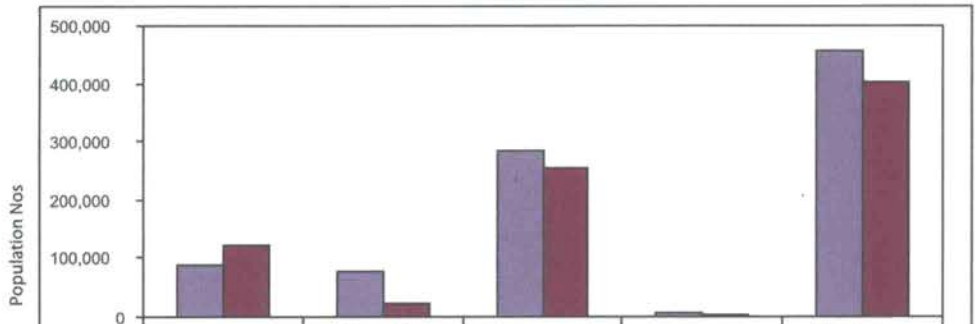
Types of wild animals

Figure 1.5 (Cont.)

c) Isiolo District

The overall livestock population in Isiolo district was 454,440 animals in 1994 and 402,430 animals in 2001. This showed a decline of 11.4% over the period. Sheep and goats population had declined significantly by almost 70.3%, donkeys by 24% and camels by 10.9%, but cattle had increased by 39% (Figure 1.6). At the peak of 2000 drought, a large number of animals was lost with almost 13,540 carcasses observed. The increase in cattle over the period was attributed to animal migrations from adjacent districts.

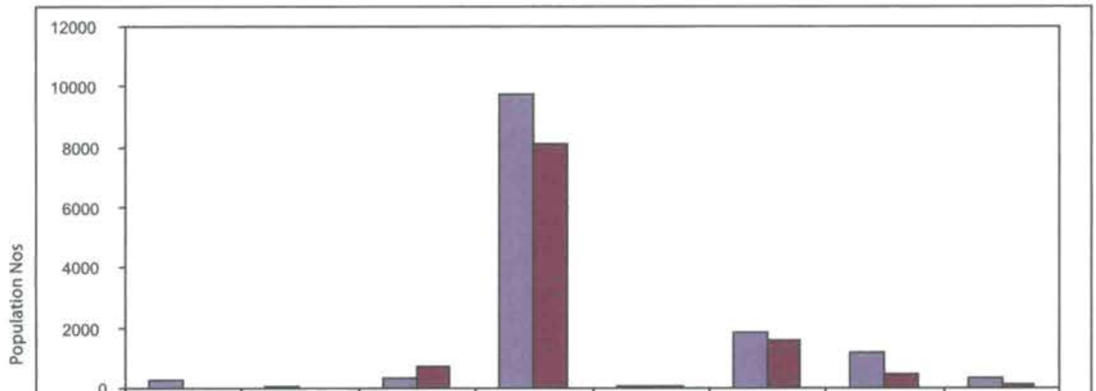
The overall wildlife (large herbivore) population was 23,184 animals in 1994 and 18,221 animals in 2001. The population of most wildlife species had declined including Grant's gazelle, Thomson's gazelle, gerenuk, giraffe, impala, ostrich, warthog, Burchell's zebra and Grevy's zebra. However, the populations of elephant, kudu and oryx had increased, probably due to migrations into the district (Figure 1.7). In the March 2000 census, the buffalo, eland and waterbuck were not observed in the district, probably due to movements out of their range.



	Cattle	Sheep & Goats	Camel	Donkey	Livestock (totals)
1994	88,180	76,810	283,570	5,880	454,440
2001	122,630	22,820	252,520	4,460	402,430

Types of Livestock

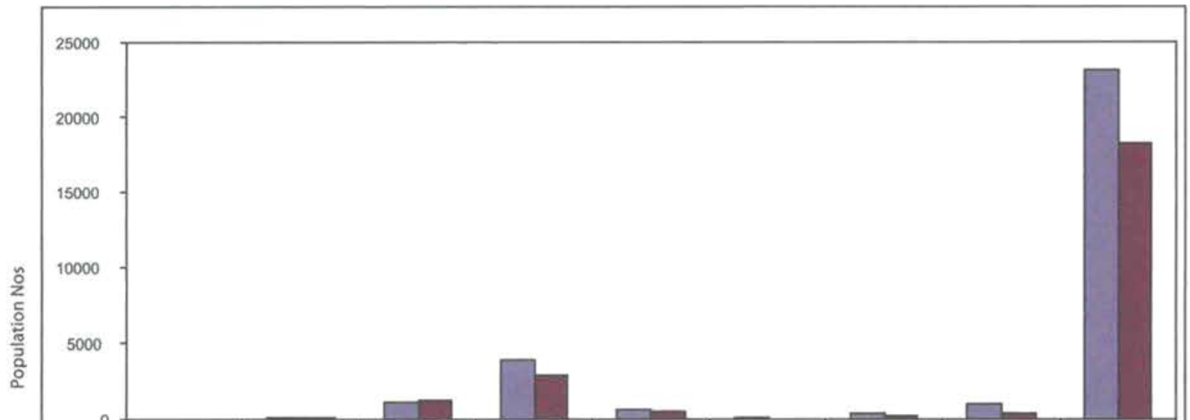
Figure 1.6 Livestock numbers in Isiolo district between 1994 and 2001



	Buffalo	Eland	Elephant	Grant's Gazelle	Thom. Gazelle	Gerenuk	Giraffe (R)	Impala
1994	270	90	350	9,740	70	1,840	1,190	330
2001	0	0	740	8,080	40	1,560	430	150

Types of wild animals

Figure 1.7 Wildlife numbers in Isiolo district between 1994 and 2001



	J. Hartebeest	Kudu	Oryx	Ostrich	Warthog	Waterbuck	Burchell's Zebra	Grevy's Zebra	Wildlife (totals)
1994	0	150	1,170	3,910	600	130	360	990	23,184
2001	0	150	1,240	2,820	440	0	220	350	18,221

Types of wild animals

Figure 1.7 (Cont.)

d) Spatial Distribution of Livestock and Wildlife in Northern Kenya

At the peak of year 2000 drought, most of the livestock and wildlife species were located within large ranches in the northern, central and southern parts of Laikipia district (Fig 1.8). Exceptions were a few species, which were observed within the drier Mukogodo area in the northeast and western, southeast and southern parts. In Samburu district, a large concentration of wildlife was observed in the eastern part and within the highlands including the Nyiru, Ndoto and Mathews Mountains. Animal mortality was high with carcasses strewn within the highlands and around Maralal town (Fig 1.9). This suggested the rampant animal movements along the rainfall gradient, as a large portion of the district had remained dry but green patches occurred in the upland bushes and mountainous areas. Finally, livestock were widely distributed in Isiolo district with large concentration in the western arm (Fig 1.8). Most of the wildlife was also widely dispersed, but in small herds within proximity of permanent water source. Large concentrations of animal carcasses were observed along the Ewaso Ng'iro River swamps, Kiboko camp, Modugashu and Benane area (Figure 1.10).

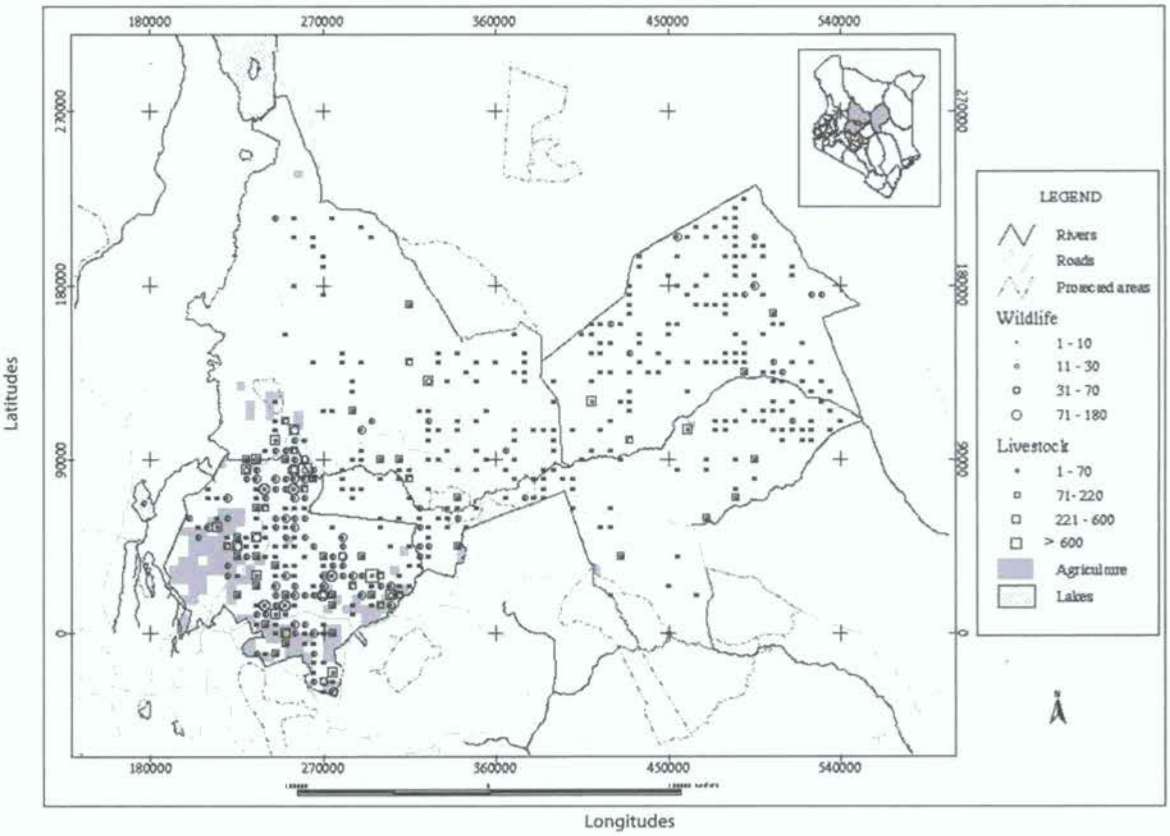


Figure 1.8 Spatial distribution of wildlife and livestock in Laikipia, Samburu and Isiolo districts (Feb - Mar 2001).

1.4 Case Study: Impact of 2000 Drought on Livestock and Wildlife in Southern Kenya

The selected southern rangeland districts consisted of Narok and Trans-mara, which covers approximately 18,573 km^2 and Kajiado covering approximately 21,852 km^2. The region is composed of highlands in the northwest and rolling plains covered by grasslands, shrubs and bushes in the larger portions of Narok and Kajiado districts. The Inter-Tropical Convergence Zone (ITCZ) generally influences rainfall in the region, but local variations in topography also play a major role in its distribution (Brown and Cocheme, 1973). A rainfall gradient runs from the drier southwest plains of Kajiado (500mm/yr) to the wetter highlands of Narok and Trans-Mara districts (1200mm/yr). Sharp increase in rainfall also occurs with altitude within the hills and escarpments (Sinclair, 1995).

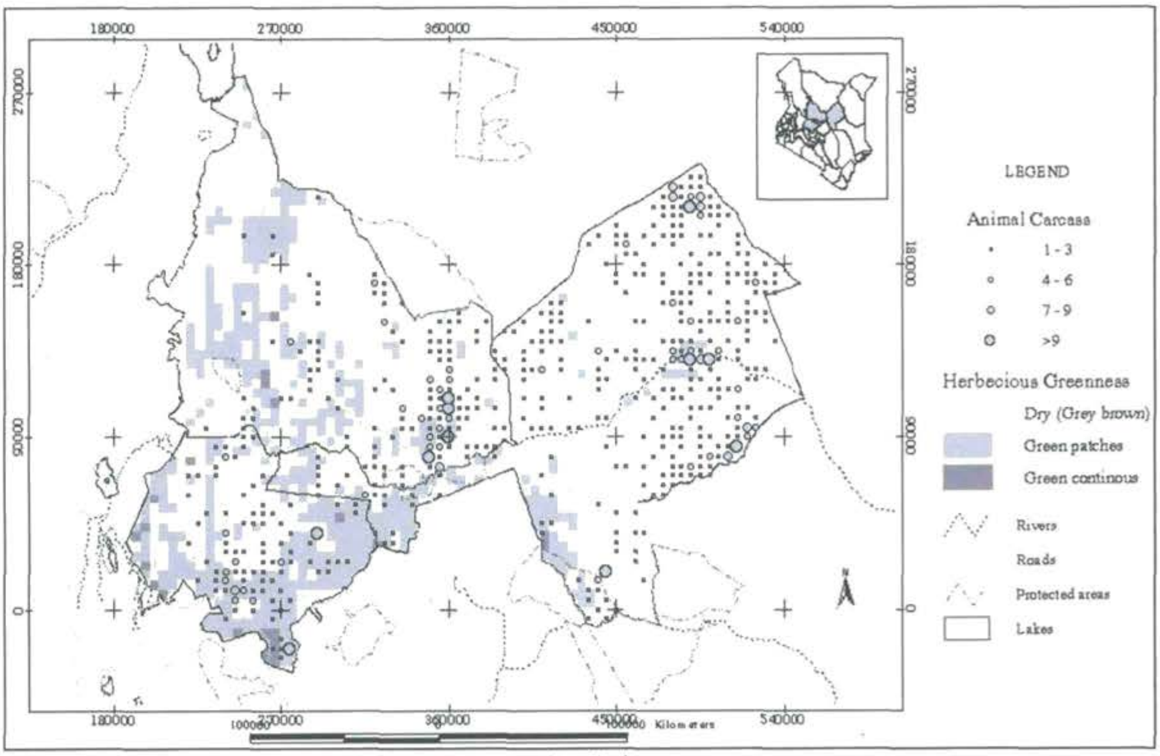
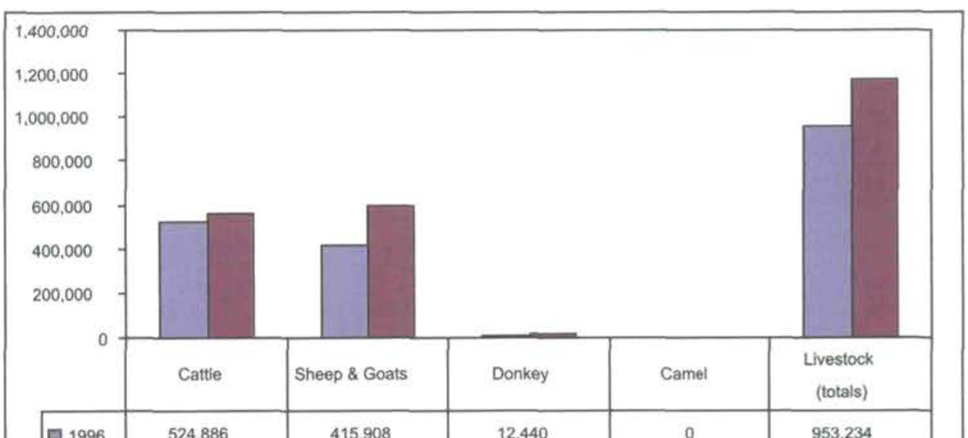


Figure 1.9 Spatial distribution of animal carcasses in relation to cultivated areas of Laikipia, Samburu and Isiolo districts (Feb - Mar 2001).

Narok and Trans-Mara (formerly the Narok district boundary as used in this report combine the two areas) and Kajiado districts host a large population of livestock (cattle, donkeys, sheep and goats). Camels were also observed in Kajiado, having been introduced into the area in the recent years. The region also supports a diversity of wildlife species, which are found in high densities within the Mara Ecosystem in Narok and widely dispersed across the Amboseli, Ewaso Ng'iro and Athi-Kapiti Ecosystems in Kajiado.

a) Narok and Trans-Mara Districts

In the two districts combined, the overall livestock population was estimated at 953,234 animals in 1996 and 1,169,741 animals in 2000. This was an increase of almost 22.7%, however the highest increase occurred in sheep and goats by 43.2% and donkeys by 19.8%. Cattle only increased by 6.5% over the same period (Figure 1.10).

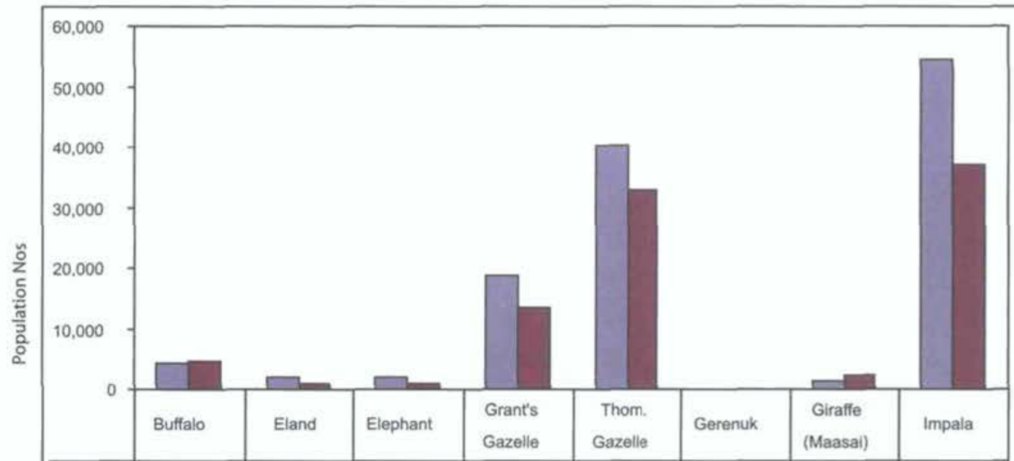


	Cattle	Sheep & Goats	Donkey	Camel	Livestock (totals)
1996	524,886	415,908	12,440	0	953,234
2000	559,252	595,588	14,901	0	1,169,741

Figure 1.10 Livestock numbers in Narok and Trans-Mara districts between 1996 and 2000

A large number of dead animals were also observed (about 3,530 carcasses) in the district at the peak of the year 2000 drought, the majority of which belonged to cattle.

The overall wildlife population had declined over the same period by more than a half, which was from 505,513 animals in 1996 to 234,363 animals in 2000. Populations of most wildlife species fell including elephant, eland, Grant's gazelle, Thomson's gazelle, impala, kongoni, ostrich, topi, Burchell's zebra, wildebeest and waterbuck (Figure 1.11). Grazers were the most affected and had declined except the buffalo. However, a large increase was observed in the browsers and mixed feeders including the giraffe, oryx and warthog.



	Buffalo	Eland	Elephant	Grant's Gazelle	Thom. Gazelle	Gerenuk	Giraffe (Maasai)	Impala
1996	4,285	1,835	2,077	18,691	40,291	0	1,350	54,584
2000	4,733	1,025	989	13,353	32,880	0	2,213	36,929

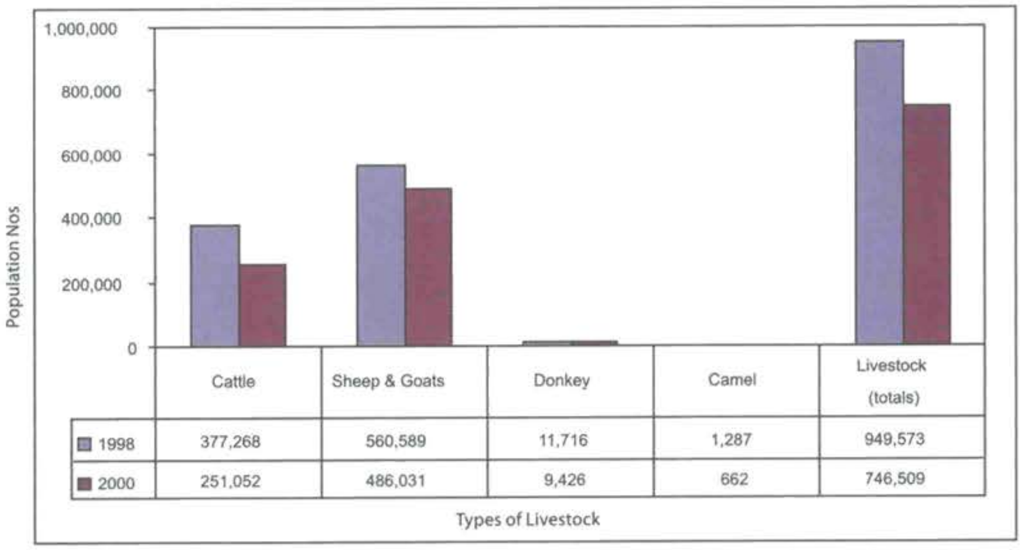
Figure 1.11 Wildlife numbers in Narok and Trans-Mara between 1996 and 2000

	Coke's Hartebeest	Kudu	Oryx	Ostrich	Topi	Warthog	Waterbuck	Wildebeest	Burchell's zebra	Wildlife (totals)
1996	2,285	0	0	934	7,107	1,419	502	297,813	72,340	505,513
2000	1,295	0	215	575	6,244	1,889	143	88,256	43,624	234,363

Figure 1.11 (Cont.)

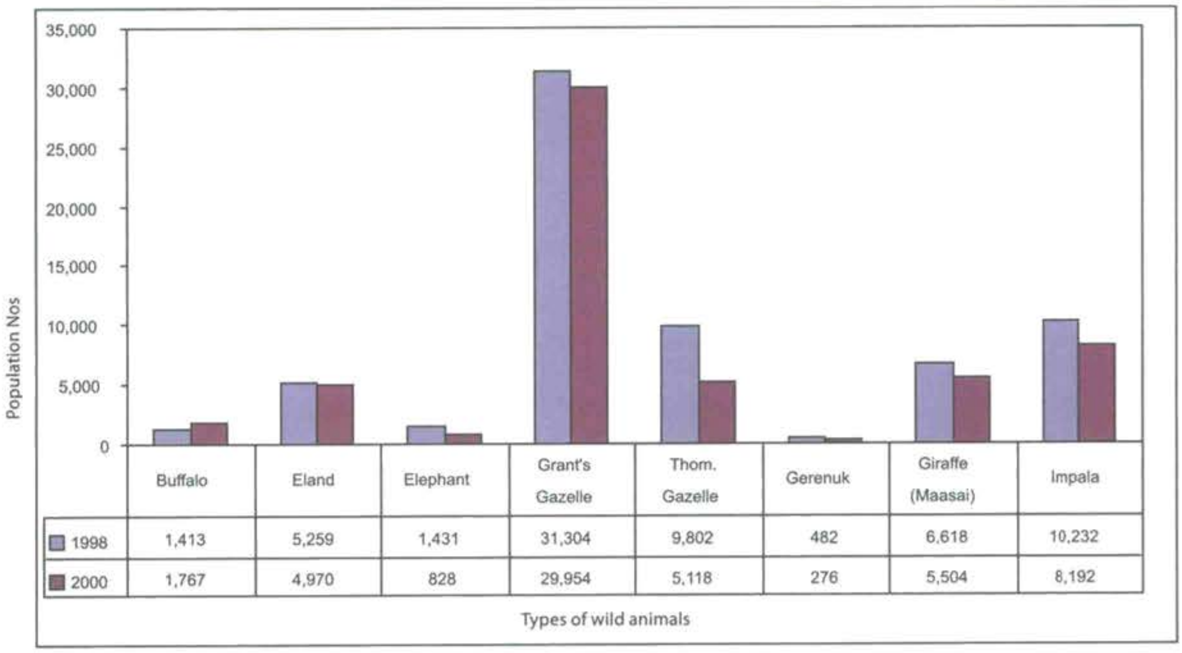
b) Kajiado District

In Kajiado district, the overall livestock population had declined by almost 21.4%. Livestock numbers were 949,573 animals in 1998, which had decreased to 746,509 animals by the year 2000. All the livestock species fell (cattle by 33.5%, sheep and goats by 13.3%, donkeys by 19.5% and camels by 48.6%) (Figure 1.12). At the peak of year 2000 drought, the animal mortality was high with almost 5,760 carcasses observed.



	Cattle	Sheep & Goats	Donkey	Camel	Livestock (totals)
1998	377,268	560,589	11,716	1,287	949,573
2000	251,052	486,031	9,426	662	746,509

Figure 1.12 Livestock numbers in Kajiado district between 1998 and 2000



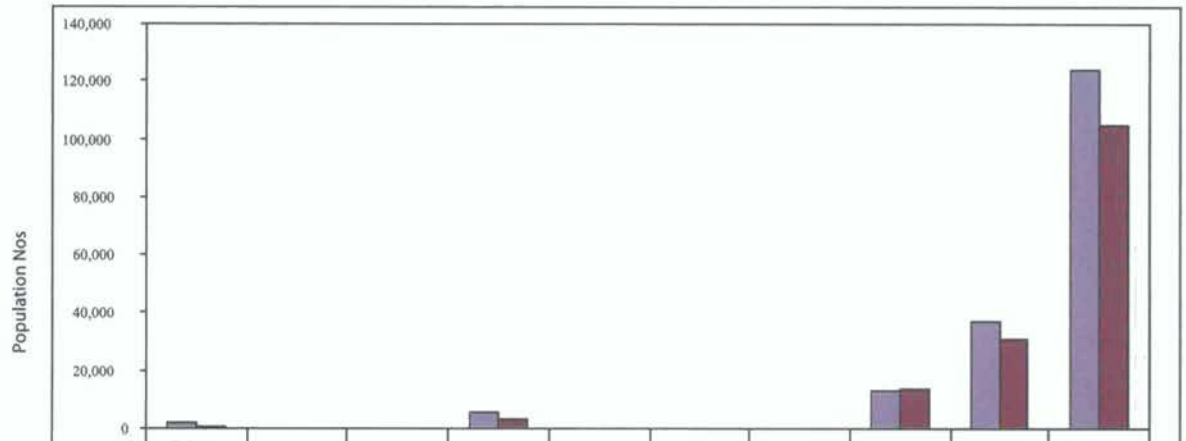
	Buffalo	Eland	Elephant	Grant's Gazelle	Thom. Gazelle	Gerenuk	Giraffe (Maasai)	Impala
1998	1,413	5,259	1,431	31,304	9,802	482	6,618	10,232
2000	1,767	4,970	828	29,954	5,118	276	5,504	8,192

Figure 1.13 Wildlife numbers in Kajiado district between 1998 and 2000

The overall wildlife population had declined by almost 15.4% from 123,621 animals in 1998 to 104,547 animals in the year 2000. Grazers were the most affected including kongoni, Thomson's gazelle, Burchell's zebra, Grant's gazelle, kudu and ostrich. Exceptions were waterbuck, oryx, topi, buffalo and wildebeest that had increased (Figure 1.13). Browsers and mixed feeders also had declined including giraffe, gerenuk, impala, elephant and warthog.

c) Spatial Distribution of Livestock and Wildlife in Southern Kenya

At the peak of year 2000 drought, livestock were widely scattered in Trans-Mara and Narok districts. Large concentrations occurred within the highlands of Trans-Mara, the Mau escarpment, Ol-Pusimoru forest and parts of the Mara Ecosystem (Loita, Mara and Siana plains)(Figure 1.14). A large herd of cattle was also observed within the Mara National Reserve (within 10 km strip along the boundary bordering Mara and Siana plains). Most of the wildlife species were observed within the Mara Ecosystem (Masai Mara National Reserve, Mara, Siana and Loita plains). A few species were observed within the cultivated areas in Trans-Mara, Loita hills and northern Narok (Figure 1.15). A large number of animal carcasses were observed widely scattered, the majority



	Coke's Hartebeest	Kudu	Oryx	Ostrich	Topi	Warthog	Waterbuck	Wildebeest	Burchell's zebra	Wildlife (totals)
1998	2,075	304	53	5,438	0	268	53	13,094	37,208	123,621
2000	828	202	147	3,387	36	165	239	13,642	31,059	104,547

Types of wild animals

Figure 1.13 (Cont.)

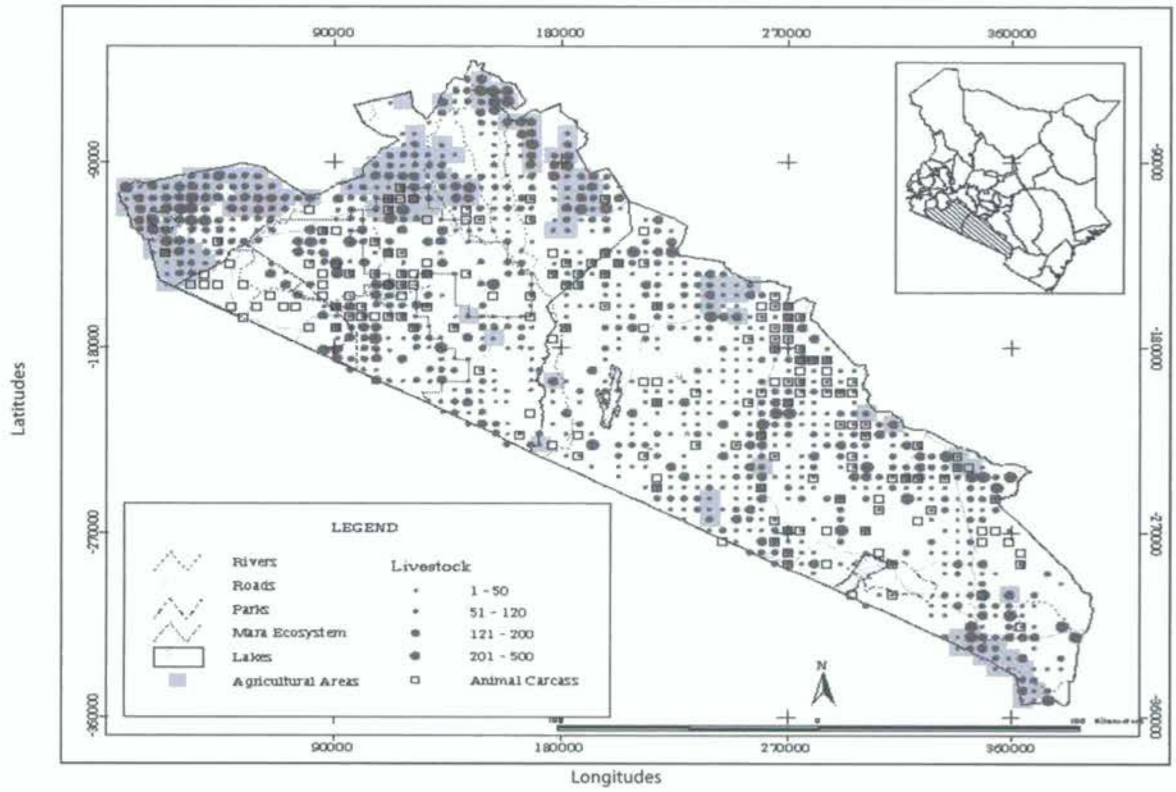


Figure 1.14 Spatial distribution of livestock and animal carcass in relation to cultivated areas in Narok, Trans-Mara and Kajiado districts (Oct - Dec 2000).

of which belonged to cattle. However, a few wildlife skeletons were also sighted inside the Masai Mara National Reserve. Large concentration of livestock occurred within the highlands and cultivation areas in Kajiado district, especially within the Oloitokitok and Rombo areas, Chyulu hills, Athi-Kapiti plains, Ngong hills and the periphery of Nairobi city (Figure 1.16). Most wildlife species were scattered into small herds and occurred within the Amboseli, Ewaso Ng'iro and Athi-Kapiti ecosystems (Figure 1.15). Animal mortality was high with large concentration of carcasses widely scattered across the plains of Kitengela conservation area, around the Athi-River and Kajiado towns, and the Chyulu hills (Figure 1.15).

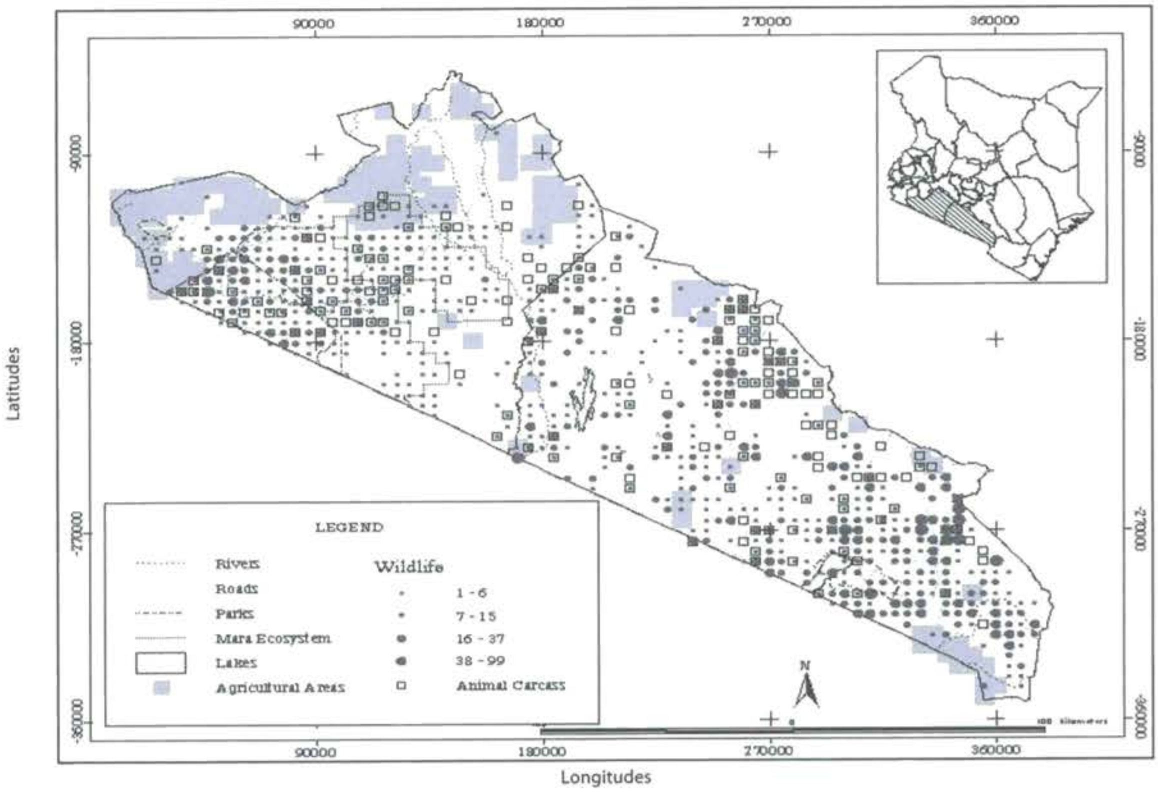


Fig. 1.15 Spatial distribution of wildlife and animal carcass in relation to cultivated areas in Narok, Trans-Mara and Kajiado districts (Oct-Dec 2000).

1.5 Discussion

The livestock populations have fluctuated over the years in the arid and semi-arid lands, but declined drastically due to recurrent droughts. The population of most wildlife species has consistently declined except those of a few species including the Burchell's zebra and elephants resident in Laikipia and Kajiado districts that have increased (Grunblatt, *et al.* 1996; De Leeuw, *et al.* 1998; Ottichilo, 2000). Drought resistant species include the Grant's gazelle, gerenuk, giraffe, kudu and Grevy's zebra also increased or remained stable in certain parts of the country. The overall decline in wildlife population is attributed to drought susceptible species including the buffalo, hartebeest, eland, Burchell's zebra and impala.

The rapid decline in wildlife and livestock populations can be attributed to a combination of factors including the counting error, drought, land use change, poaching and competition for water and forage among others.

(a) Counting error: Counting error may contribute considerably to fluctuations of population estimates (Norton-Griffith, 1978; Ottichilo and Sinange, 1988). However, tests performed by DRSRS on visibility bias in the Mara ecosystem have shown that the counting efficiency was 70-80% on wildlife and 80-90% on livestock (Stelfox and Peden, 1981). The departments' animal census methodology has remained the same over the years, holding the assumption that visibility bias has also remained constant. It can be concluded that the declines in resident species (non-migratory) reflect the true change.

(b) Drought: The effect of climatic variations, mainly the drought is a single most important factor responsible for abrupt extermination of large population of animals over wide areas. The severe drought 2000 was mainly responsible for high declines of large herbivore populations and shift in their spatial distribution in the rangelands. The animal census showed remarkable loss of livestock (mainly of cattle, but also sheep and goats) in Laikipia, Samburu, Isiolo, Narok and Kajiado districts. The pastoralists interviewed also reported huge losses of herds and very low market price on animal products. Large concentration of animals also occurred in certain localities as a result of rampant movements within and from the adjacent districts in search of water and pasture. Lamprey (1983) observed that irregularity of rainfall in the arid zones causes fluctuation in the production of vegetation, which in turn influences livestock numbers in response to increased/decreased food availability. Drought-induced mortality of 1979-80 led to loss of almost 50-70% of the livestock in Turkana district (Ellis & Swift 1988). Jacobs & Coppock (1999) also reported high cattle mortality in northern Kenya in 1984-5, 1991 and 1997, while Homewood & Lewis (1987) reported 50% decline of livestock in Baringo district in the 1984 drought.

In drought years, forage and water become limiting to wildlife and livestock, hence their populations decline either through the effects of reduced reproduction, starvation-induced mortality or migrations. The drastic change in vegetation cover due to severe lack of available moisture resulted in massive loss of large herbivores in the year 2000. Numerous animal carcasses strewn widely within the study area was a clear indication of starvation related mortality (Fig. 1.16). As the effects of drought weakened the animals, they also succumbed to diseases. A total of 3,980 animal carcasses were sighted in Laikipia district, 13,540 carcasses in Isiolo district and 5,380 carcasses in Samburu district. Laikipia depicted a lower carcass ratio (0.9% of the total large herbivores in the district) as compared to Samburu (1.2%) and Isiolo district (3.1%), which suggested that the habitats in Laikipia were more resilient than those in the latter districts.

Figure 1.16 Animal bones from the 2000 drought.
Photo by P.Smerdon (WFP)

The distribution of carcasses also corresponded to the patterns of animal movements between the districts and from outside. The three districts are arrayed along a rainfall gradient with Laikipia always the wettest and Isiolo the driest. In the southern rangelands, almost 3,530 animal carcasses were sighted in Narok and Trans-Mara, which represented 0.25% of the total large herbivores in the districts, while almost 5,760 carcasses or 0.67% of large herbivores were observed in Kajiado.

The long-term trends of livestock in the rangelands show fluctuations of cattle numbers with dramatic declines during droughts. A significant decline in cattle numbers was observed in Narok district between 1977-88, but remained stable between 1983-1997 (Ottichilo, 2000). The decline in cattle between 1983-84, 1991-92 and 1999-2000 was attributed mainly to the droughts. Cattle numbers will recover rapidly from drought effects at onset of the rains. The spatial and temporal fluctuation of cattle therefore corresponds to variability of rainfall during primary productivity rather than indicating long-term trends. Camels can easily cope with drought conditions, however their numbers had reduced in certain areas due to rampant movements within and between the districts. In times of droughts most wildlife are also affected, but certain species such as gerenuk, oryx, Grevy's zebra and Grant's gazelle appear less affected due to their adaptability to arid conditions.

(c) Land use change: Habitat change due to alteration of vegetation cover and land use has been studied and quantified (Dublin, *et al.* 1990). However, the link between these factors and wildlife population dynamics is yet to be established. In the last few decades, land use change had a major impact on populations of most wildlife species in the rangelands. Modification or loss of habitat is crucial to the existence of wildlife (Morrison *et al* 1992). The introduction of new land tenure systems in the arid and semi-arid lands (ASALs) and creation of group ranches to assign rights and responsibilities of ownership to specific pastoral communities (Langat 1986; Pasha 1986) led to the modification of principal wildlife/livestock grazing areas. The problems associated with growth of human population and increase in wildlife and livestock combined with finite range resources are still contentious issues. The impact of group ranches and individual ownership on wildlife is the exclusion of species from their properties to minimize competition with livestock. This has been aggravated by the fact that wildlife does not directly benefit private landowners in terms of economic returns. On the other hand, increasing land use pressure and conflicts within group ranches has led to the sub-divisions of large tracks of land into small units, a development which severely curtails free movements of wildlife. The promotion of arable land use in the ASALs has contributed immensely to declines of wildlife and livestock populations as wet season dispersal areas have diminished. Serneels, *et al.* (in press) has reported that a large proportion of the vegetation cover in Narok was altered considerably between 1975 and 1995 due to expansion of cultivation areas. Ottichilo (2000) argued that the wildebeests within the Mara ecosystem had declined largely due to the significant expansion of cultivation especially of wheat farming (Karime 1990).

Vast areas of Kajiado district were turned into group ranches and wildlife management zones including the Athi-Kapiti and Kitengela plains, Kimana wildlife conservancy and Amboseli national park. At the beginning of 20th century, the Kitengela plain was part of a large ecosystem that covered areas between Embakasi and Kilimambogo hills. However, this ecosystem has since shrunk considerably due to changing human settlement patterns, effects of nearby industrial activities and the expansion of Nairobi city. The impact of habitat loss on wildlife is the decline in populations of various species (Prins and Olff, 1998. Thouless (1993) also reported that the decline of wildlife in the pastoral areas of Laikipia and Samburu districts were due to increased livestock and human populations. Social pressures have often succeeded in alienating wildlife habitats, while associated land use activities have aggravated the unsustainable exploitation of resources (McNeely 1992). Unsustainable land use activities, extensive shrinkage of dry season grazing areas and competition for forage and water resource among other factors aggravated the severity of year 2000 droughts in many parts of the country. Other forms of environmental degradation include destabilization of water catchments through clearing, charcoal production and firewood requirements.

(d) Spatial distribution of animals: In the arid and semi-arid lands, the rains are often inadequate and highly variable both in temporal and spatial scales. The primary productivity closely follows the rainfall patterns, which also determines the pattern of spatial distribution of animals and in turn regulate the population size and home range. The resultant species densities will vary according to whether the underlying habitat changes are regular in space and time, and accordance to magnitudes in terms of forage quantity and quality (Prins and Olff, 1998). In the northern Kenya rangelands, severe droughts occurred between 1983-84, 1985-86, 1992-93 and 1999-2000. During these periods, very low primary productivity and lack of water resulted in shortage of forage. The latter drought was responsible for drastic decline in populations of most large herbivores. Far less animals were observed within the drought stricken areas because the pastoralists moved away their livestock in search of pasture. Wildlife species too migrated or dispersed to areas with better pasture and reach of water. The movement of livestock from Garissa and Tana River districts into Isiolo was clear evidence as to how wide the animals often move during periods of environmental stress (Kufwafwa, 1985). A large number of livestock were also moved from Wajir district into Isiolo during the 2000 drought. This was probably due to the presence of the Ewaso Ngiro River that provided green flush and water in the latter district (Wargute 2004). Similarly, large herds of livestock were moved from Baringo and Laikipia into Mt. Kenya region to escape the scourge, a move that was ascribed to pastoralists' opportunistic strategic management by exploiting sporadic environment to evade massive livestock loss (Sandford 1983). While movement of animals into the mountains was viewed as a solution to provision of green pasture, animals still died in large number due to the cold environment and pneumonia.

Certain wildlife species exhibit migratory behaviour in response to resource scarcity as dictated by seasonality. Perhaps this was why certain species were less affected by the drought than others. For instance, the elephants in the Laikipia region are known to move onto the plateau at the beginning of the dry season, but will disperse northward towards the pastoral areas in Samburu and Isiolo in the advent of short rains. Many of these animals return to the Laikipia plateau at the end of short rains and then disperse northwards once again at the beginning of long rains (Thouless 1995, 1996). This was clearly demonstrated by the variation of elephant population within the districts during the drought. Rainy (1980) also reported that Grevy's zebra, Burchell's zebra, oryx, Grant's gazelles, ostrich and giraffe exhibits migratory tendencies, which may have contributed to their low numbers during the drought.

Figure 1.17 Cattle grazing in the Masai Mara NR Reserve at the peak of the year 2000 drought. *Photo by G.O. Ojwang'*

Wild ungulates will often distribute themselves so as to avoid interactions with pastoralists and their livestock. In most cases, the greatest diversity and abundance of wild ungulates occur in places excluded from livestock i.e. in the parks and game reserves. The spatial distribution of large herbivores in Narok district reveals that most animals were widely dispersed within the Mara ecosystem at the peak of 2000 drought. However, the wildlife avoided large herds of cattle that were moved into the park (Figures 1.14, 1.15 and 1.17). This may suggest that certain wildlife species were displaced by livestock through competition for forage or aggression by the pastoralists along the park boundary.

(e) Poaching: The illegal killing of wild animals is the most publicized threat to the arid and semi-arid lands. Elephants and rhinos have already been eliminated from much of their former range. However, a relatively large population of these animals still exist in highly protected enclaves within the parks and private ranches including the Amboseli National Park, Masai Mara National Reserve, Kimana Wildlife Conservancy, Lewa Downs and some private ranches in Laikipia. Wildlife poaching may occur for various reasons including commercial purposes (for sale of trophies) and subsistence needs. In Kenya, the use of bush meat along with other value added activities were banned in 1977, but at a recent conference in Mombasa it was reported that the rate at which wildlife are now being killed for bush meat trade is unsustainable and the off-take unacceptable. The Director of the East African Wildlife Society said that 'after charcoal burning, the bush meat trade is the second successful *jua kali* business in Kenya' (Nation Newspaper, 24th May 2004). During droughts, large populations of wildlife often migrate or disperse widely and sometimes wonder close to human habitations. At these points, they become more vulnerable to be killed for the pot, especially when the effects of drought and lack of food also hits the communities. The pastoralists may also harvest these animals particularly the young herd boys who are adept with a variety of weapons ranging from spears, bows and machetes. Snares have been deliberately set to supplement meat requirements in the adjacent areas to the park. A survey shows that 58% of Kenya's wildlife has been lost in the past 20 years, which was attributed to bush meat trade (Nation Newspaper, 24th May 2004). The impact of poaching is difficult to assess, since evidence is often circumstantial and largely unavailable for records. A recent socio-economic survey in Narok district showed that poaching was rampant in the Mara ecosystem in late 1970s and early 1980s than it is today (Ngene and Kariuki, 1999). Sitati (1997) reported increased poaching by the Maasai for subsistence needs, but it remains unclear whether this trend is related to rapidly changing culture or a means of supplementing meat requirement during the drought. Rampant poaching for the pot if not checked may contribute significantly to reduction of animal populations in certain areas.

(f) Resource use: Abundance and spatial distribution of large herbivores is highly related to availability of quality forage and water resources (Prins 1992), which closely follow the spatial and temporal pattern of rainfall distribution. Some animals will therefore occur in large concentration within areas of high rainfall than the more arid ones. The opportunistic response to forage and water availability also triggers movements of pastoralists' with their livestock over wide areas. These erratic wondering correspond to the presences or absence of rains and results in patterns of aggregation and dispersion that often affect the grazing intensity. To counteract the fluctuation in forage availability, the Maasai livestock management strategy is to reduce small stocks and increase cattle numbers during wet seasons, but shift to sheep and goats during dry periods (Swift *et al.* 1996).

The spatial distribution of large herbivores may give the impression that several species of different body sizes occur in the same area and utilize similar feed resources. Most large herbivores are complementary rather than competitive in many respects and separated both in forage selection and preference (Lamprey 1963; Leuthold 1977; McNaughton and Georgiadis 1986). They also differ widely in adaptive strategies to forage shortage and quality changes. Most herbivores are adapted to fluctuations in forage quality by either more efficient digestion of poor quality materials or increased selectivity of high quality plant parts. However, the potential for competition between wild ungulates and domestic stock exists, and relatively low numbers of mixed species found in the same habitat only present the expected grazing pressure complement.

During the 1999-2000 drought, sheep and goats had increased in many areas, which can be attributed to their adaptability to 'harsh' environmental conditions and ability to reproduce quickly. Sheep and goats are mixed feeders, with sheep having a high preference for short grasses and forbs, while goats prefer browsing materials. However, it can be argued that the rapid decline of these animals in other areas was attributed to change in vegetation cover, mainly the loss of herbaceous layers and shrubs and migrations. Donkeys increased over the same period in certain areas, which can be attributed to their adaptability to poor forage utilization and influence of pastoralists' movement. Camels can live for long periods without water and browses on shrubs and bushes at various strata, which highly contributed to their survival during the drought.

1.6 Conclusion and Recommendations

Kenya was hit by a series of droughts in 1991/92, 1996/97 and devastating floods in 1997/98. The 2000 drought occurred against a background of long-term economic recession, where water requirement, food and security affected almost every sector. The semi-arid and arid areas were worst hit due to severe lack of available water, which in turn led to the massive loss of vegetation cover and subsequent death of large populations of animals. The loss of animals was a huge setback to the national economy. The recovery process may be slow especially among the poor rural communities and therefore the affected people especially the pastoralists needed assistance in restocking their herds after the disaster.

Several factors that had aggravated the severity of drought included the prior consecutive dry spells, change in land use activities, sub-divisions of communal lands used as dry season dispersal areas and environmental degradation among others. These contributed negatively to the availability of forage and water, which in turn led to dehydration and starvation related mortalities. The enactment of adequate land use policy, community participation in drought mitigation and management and land consolidation for management purposes such as group ranching enterprises and wildlife management adopted by wildlife forums in Kajiado, Narok and Laikipia districts offer promising land use alternative for the arid and semi-arid lands. Small-scale land management units are often unsustainable in these areas as they provide relatively low resources and per capita income.

The lessons learnt from the 2000 drought calls for urgent intervention measures, including disaster preparedness and early warning systems for natural disasters to facilitate reduced vulnerability of the local communities and their livestock, wildlife as well as the environment in general. Of particular attention is the need to build up local capacities and coping mechanisms in dealing with problems associated with recurrent droughts. Contingency planning and intervention are urgently required in the event that the rains failed again after dry spells. This will prepare the communities for livestock restocking and wildlife managers in range management and disease surveillance.

Since much of Kenya is disaster-prone, there is urgent need for detailed national monitoring surveys to assess the status of natural resources, especially land cover/use and animal populations. In early 1990s, the Department of Resource Surveys and Remote Sensing (DRSRS) was able to conduct such periodic surveys in the entire rangelands on regular basis through funds from the World Bank. Following the end of the facility, surveys have been inconsistent while at times only portions of ecosystems are surveyed. Consistency and reliability of information is crucial in efficient planning and management of existing natural resources.

Most of the large herbivores were severely affected by the drought irrespective of their range. The grazers, mainly livestock were the most affected and many starved to death. However, other species including browsers and mixed feeders also suffered from lack of available forage and water. The movement of animals during the drought and subsequent concentration of large population within the cultivated areas and water points was responsible for increased conflicts amongst and between different communities. However, the pastoralists' livestock management strategy played a major role in maintaining viable populations for restocking when the drought ended.

CHAPTER 2

USE OF SATTELLITE DATA IN DROUGHT MONITORING

2.0 Introduction

Drought has been occurring frequently in the Horn of Africa with detrimental effects on the people and especially the economies of the Inter Governmental Authority on Development (IGAD) sub-region. The consequences of drought in the sub-region are severe because these countries depend largely on agriculture, livestock production and tourism. For example during the drought of 1984/1985 in Ethiopia alone, an estimated 8 million people were affected, 1 million died and large numbers of livestock were lost (Hutchison, 1991). The seven IGAD member states (Djibouti, Sudan, Eritrea, Ethiopia, Kenya, Somalia and Uganda) have been addressing the environmental disasters caused by drought, desertification and food insecurity.

Drought is categorised as a slow onset disaster. Although predictable, its start and end can be very elusive, while its effects are felt for a long time. In Kenya, the impact of drought is exacerbated by the fact that over 70% of the country which is rangelands, is usually hard hit by any occurrence of drought, often resulting in massive loss of livestock and wildlife.

2.1 Existing Drought Monitoring and Early Warning Initiatives

There are several institutions in Kenya involved in drought monitoring and early warning (EW) activities. These include the Kenya Meteorological Department (KMD), The Department of Resource Surveys and Remote Sensing (DRSRS), The Ministry of Agriculture (MoA), and the Arid Lands Resource Management Programme (ALRMP). KMD provides daily weather forecast, seasonal weather outlook, distribution of rainfall anomalies maps and bulletin on crop performance. DRSRS uses remote sensing techniques to monitor environmental conditions. The Arid Lands Resource Management Programme (ALRMP) has an early warning programme currently covering ten arid and semi arid districts. The early warning programme targets households and communities using locally recruited monitors. The categories of indicators monitored are:

- Rural economic indicators
- Human welfare indicators
- Environmental indicators

The results of these activities are disseminated using quarterly bulletins. Predetermined warning stages are used to facilitate interpretation of results and elicit responses. These early warning signals are normal, alert, alarm and emergency to determine the situation in the district.

At the regional level, the two main institutions that provide a wide range of information including socioeconomic indicators relevant in drought monitoring and mitigation are the Drought Monitoring Center (DMC) under IGAD, and the Famine Early Warning Systems Network (FEWS NET). DMC uses the climatic parameters such as rainfall intensities, drought indices and temperature provided by meteorological stations to provide EW information on drought in the horn of Africa.

2.2 Need for Efficient and Reliable Early Warning System

The survey carried out in the six ASAL districts after the 1999/2000 drought reinforced the need for an efficient early warning system (EWS). Most respondents (95%, in Kajiado) said they did not receive any early warning information of the impeding drought. This shows that the EWS information only reaches a very small proportion of the intended targets. Most respondents (85 % in Kajiado) said they were ready to sell their livestock to avoid losses if they got credible and reliable EWS information to avoid losses witnessed in the 2000 drought. This shows an attitude change among a section of the Maasai who have been very reluctant to sell their stock due to their traditional attachment to livestock.

2.3 Drought Indices

A drought index value is typically a single number, far more useful than raw data for decision-making. They include several climatic indices that measure how much precipitation for a given period of time has deviated from historically established norms, calculated from weather station records. The indices assimilate thousands of bits of data on rainfall, stream flow, and other water supply indicators into a comprehensible big picture. Each index is better suited than others for certain uses. Percent Normal (PN), Water Requirement Satisfaction Index (WRSI), Meteosat Rainfall Estimation (RFE) and Normalized Difference Vegetation Index (NDVI) are among the common indices used for drought monitoring in the country. Other indices used in other parts of the world include Palmer Drought Severity Index (PDSI), Standardized Precipitation Index (SPI), Crop Moisture Index (CMI), Surface Water Supply Index (SWSI) and Reclamation Drought Index (RDI). The various indices provide some form of quantitative parameters which are used to classify or predict drought over varying periods of time even though the applicability of each is limited, making the identification of region specific indices appropriate.

Percent of Normal

This is the simplest measurement of rainfall for a location. The analysis of percent of normal is very effective when used for a single region or a single season. It is calculated by dividing actual precipitation by normal precipitation (typically considered to be a 30-year mean) then multiplying by 100% and can be calculated for a variety of time scales that range from a single month to a group of months representing a particular season. This is one of the indices used at the Drought Monitoring Center to monitor drought in the country and the horn of Africa (fig. 2.0). They also give drought severity indices based on the same method.

Water Requirement Satisfaction Index (WRSI)

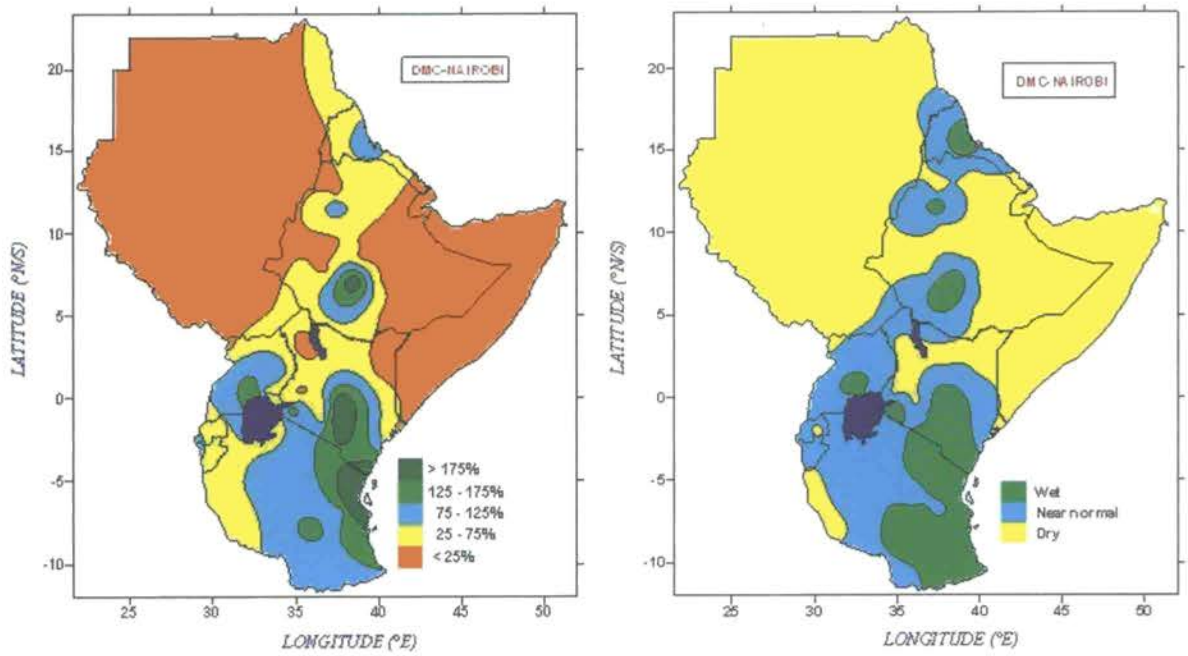
This is an indicator of crop performance based on the availability of water to the crop during a growing season. WSRI for a season is based on the water supply and demand a crop experiences during the growing season. It is calculated as the ratio of seasonal actual evapotranspiration to the seasonal crop water requirement. This is one of the useful early warning products given by FEWSNET.

Meteosat Rainfall Estimation (RFE)

Meteosat rainfall estimation imagery (RFE) is calculated from satellite data and rain gauge information for rainfall estimation. This information is used for input for hydrological and agro meteorological models and is provided on the FEWSNET website.

Normalized Difference Vegetation Index (NDVI)

NDVI was chosen as proxy index for this study because effort to monitor the droughts using weather data in the country is hampered by sparse meteorological network and unavailability or incomplete data. This scarcity of vital weather data was addressed by using satellite-derived NDVI, which is readily available on a daily basis covering the entire country and provide a more accurate index of actual drought conditions than the climate-based indices. NDVI indices are highly sensitive to rainfall anomalies, allowing NDVI to be used as a good indicator of climate variability. NDVI has been used extensively in vegetation monitoring, crop yield assessment /



Rainfall anomaly, February 2004 *Drought severity, February 2004*

Figure 2.0 Drought monitoring products calculated as percent of normal from DMC website. The products show rainfall anomaly and drought severity for February 2004 respectively for the horn of Africa. *(Source: DMC)*

forecasting and drought monitoring and mapping (Tucker, 1987; Tucker and Choundury, 1987; Kogan and Sullivan, 1993; Ungunai and Kogan 1998).

The two characteristics of NDVI that make it ideal for vegetation monitoring are that no other surface exhibits higher NDVI than vegetation surface and when vegetation vigor changes due to nature of the vegetation growth and development or environmental induced stress such as drought the NDVI also changes (Tucker and Choundury, 1987).

2.4 Analysis of NDVI data

Qualitative and quantitative approaches in NDVI analyses were used to detect drought occurrences between 1998 and 2004. The qualitative analyses were based on the images from SPOT 4 vegetation data for the years 1998 to 2000. During this period, the country experienced extreme climate fluctuation namely the El Niño phenomena in 1997-1998 and the severe drought in 2000. The NDVI images were used to monitor the vegetation phenology over the country. They have been used in this exercise to show the agro-climatic conditions prevailing in the country between 1998 and 2000. For the quantitative analyses, NOAA NDVI images reflecting the trend in biomass availability between 1982 and 2004 was extracted from the USGS website and mean annual 'greenness' index based on selected districts analyzed using WINDISP software.

To characterize the climatic fluctuations, the satellite images from NOAA/AVHRR were used to evaluate the inter-annual variation in vegetation conditions. The Normalized Difference Vegetation Index (NDVI) anomalies were calculated for the time period 1982-2004 using the *z*-transform ($(x_i-\mu)/\text{std}$), where x_i being the NDVI value for a given month in year *i*, μ the mean NDVI for that month across all years, and *std* the standard deviation of the NDVI values for that month across all years (Serneels et al., 2001; Anyamba et al., 2001; Said 2003). Analysis was then performed on the resulting anomaly deviations a particular year in question providing the drought severity scale using arbitrary thresholds.

2.5 Outputs

2.5.1 Drought Monitoring at National Scale

The qualitative monitoring using NDVI products are based on performance of rainfall regime. Generally, most of the country because of its equatorial location receives a bimodal rainfall distribution. This is characterized by two rainy seasons as well as two dry seasons. The long rains occur in March - May, while the short rains occur in November - December. The synoptic NDVI products for 1998 shows that the long rains were well received and distributed all over the country (Figure 2.1). The only dry areas as the rains progressed were the areas surrounding Lake Turkana. The rest of the country was generally green peaking at the end of May. Similarly, the short rains (Figure 2.2) were also favourable, but with less intensity compared to the long rains as shown by the vegetation condition all over the country during that period. The Turkana region, some portions of the coast and northern Kenya remained fairly dry. Generally 1998 was a wet year for the country owing to the *El Niño* phenomena prevailing at that time where most of the country received above normal precipitation. This is well reflected in the NDVI products for that year. However, it was in sharp contrast to the NDVI product for the long rains of 2000 (Figure 2.3), a drought year. The NDVI images show that the rains were not well spread out and most of the country remained dry even at the peak of the long rains (1^{st} - 3^{rd} Dekad of May). This was also the same for the short rains (Figure 2.4). The NDVI results for this year reflected what was happening in 2000 because most parts of the country recorded the worst drought over the last two decades.

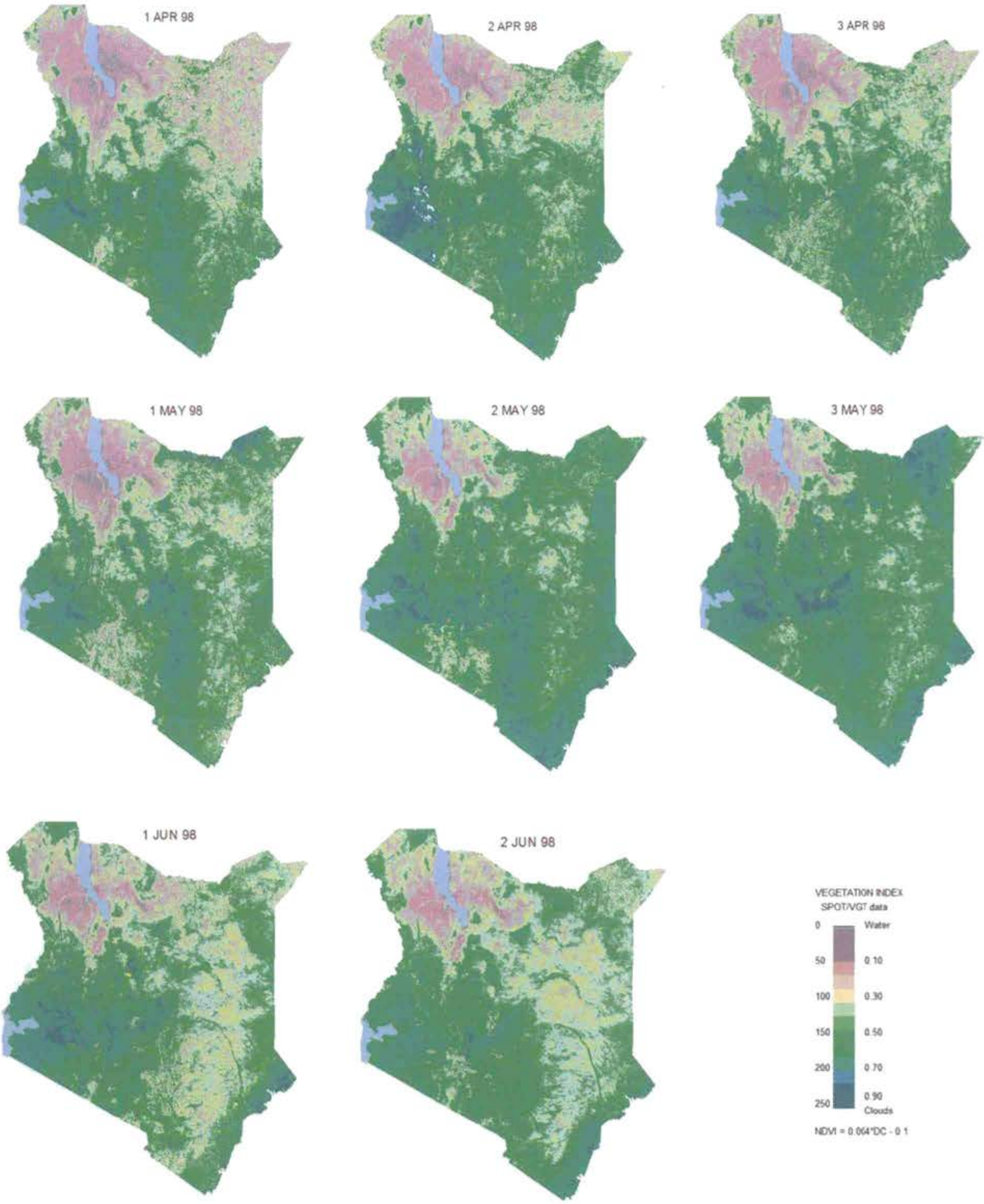


Fig. 2.1 The images were processed from SPOT4 vegetation data showing the long rains of 1998. The legend range of 0-1 indices value on indicates increasing vegetation greenness.

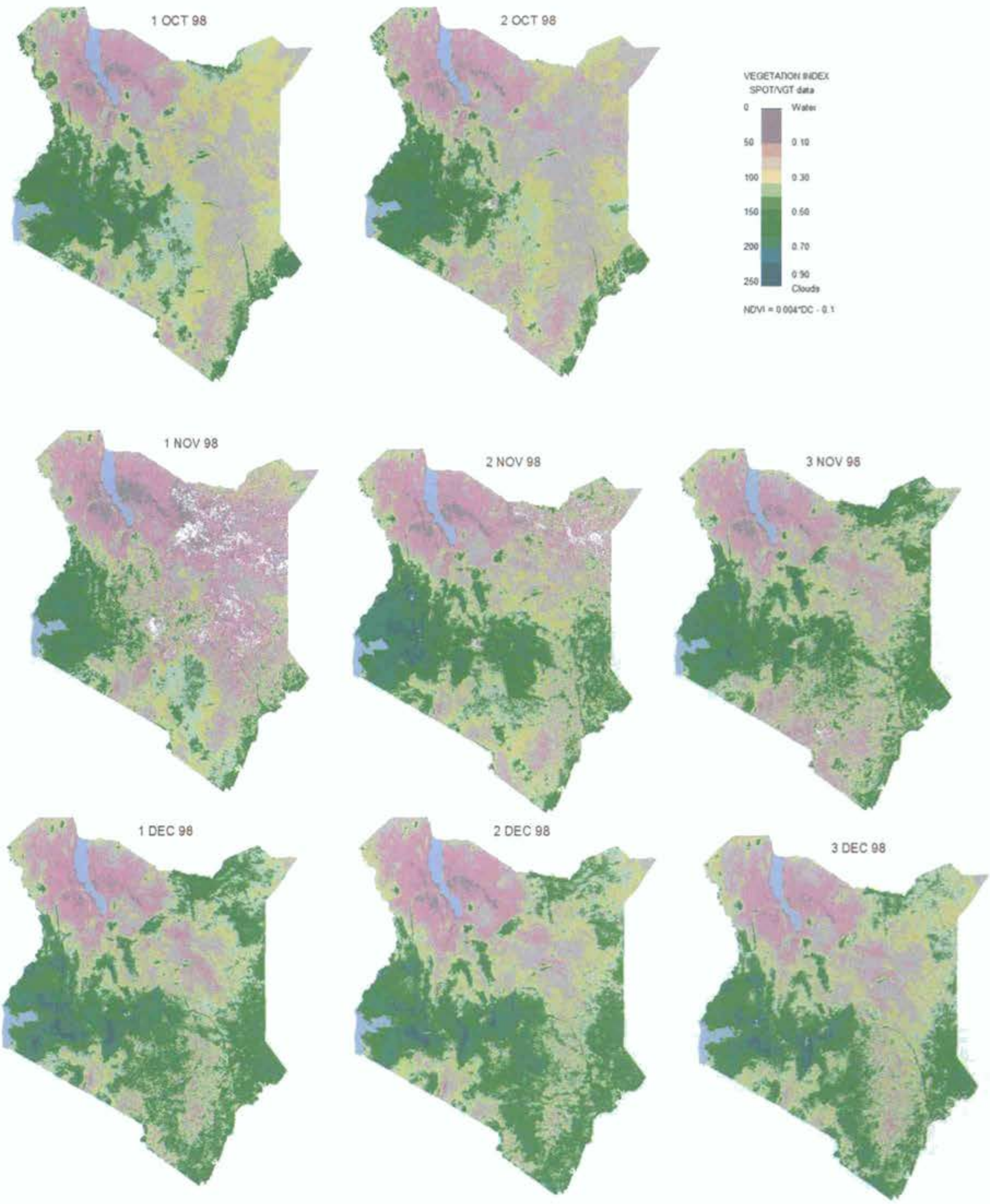


Fig. 2.2 The images were processed from SPOT4 vegetation data showing the short rains 1998. The legend range of 0-1 indices value on indicates increasing vegetation greenness.

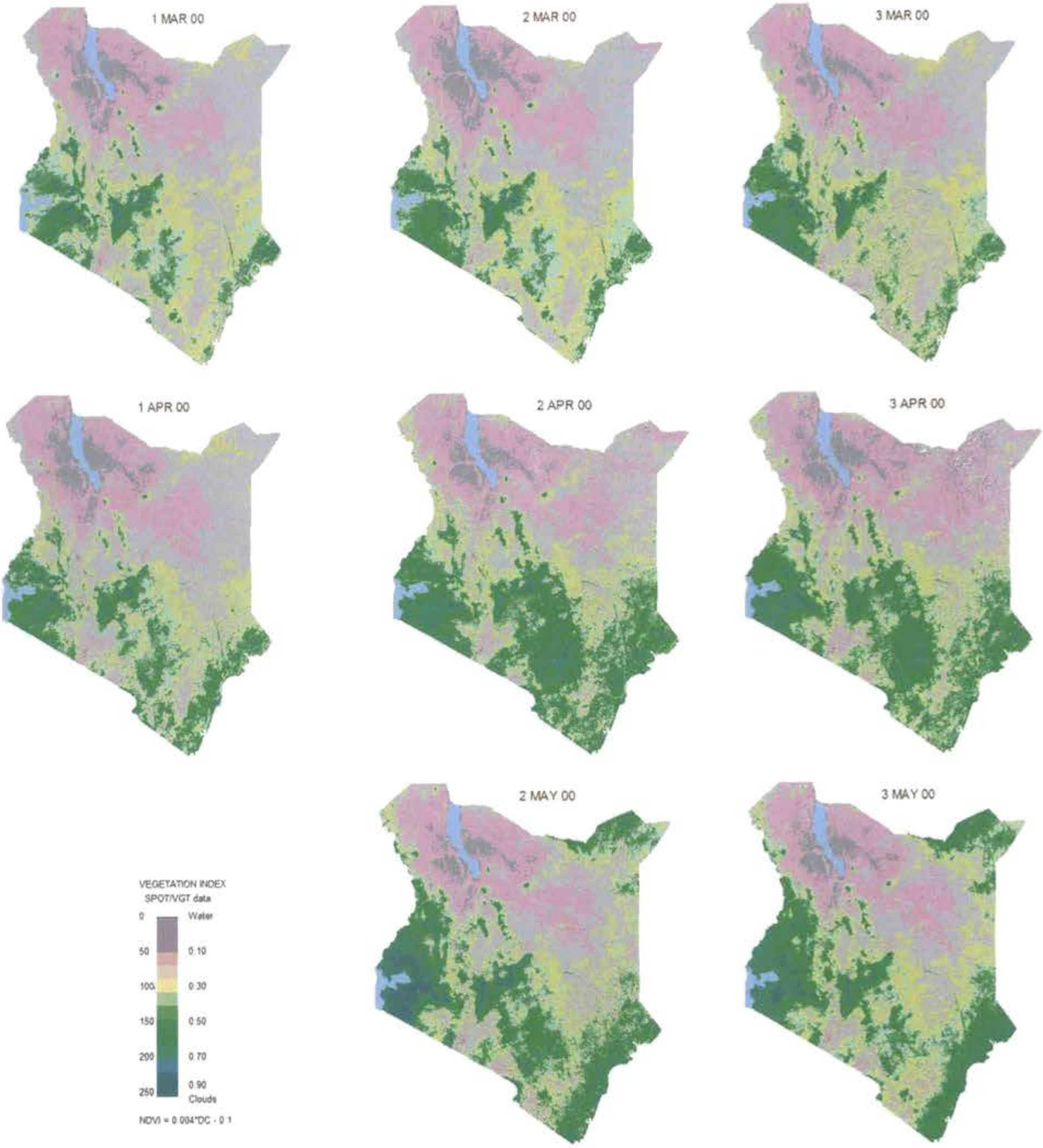


Fig. 2.3 The images were processed from SPOT4 vegetation data showing the long rains 2000. The legend range of 0-1 indices value on indicates increasing vegetation greenness.

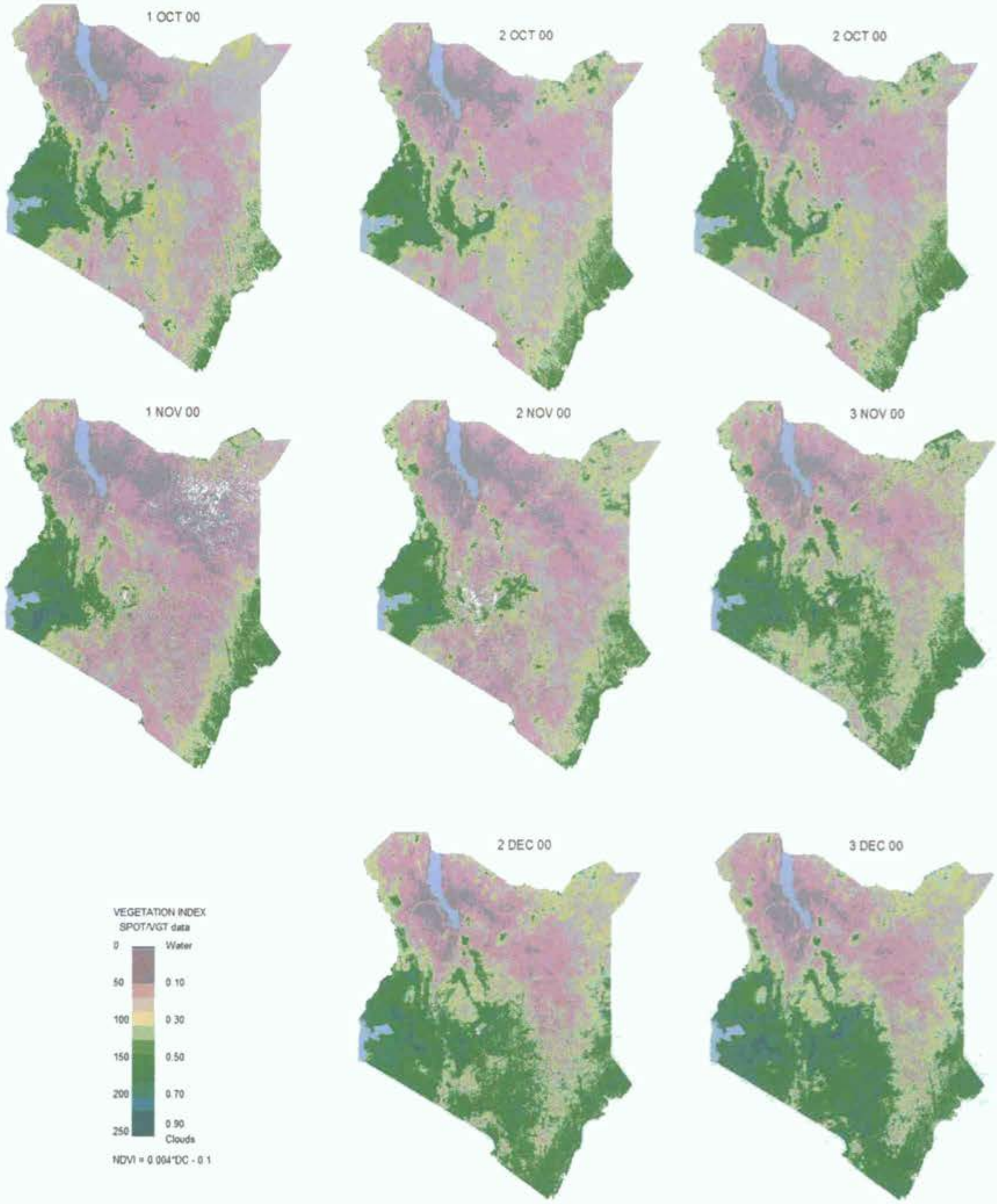


Fig. 2.4 The images were processed from SPOT4 vegetation data showing the short rains 2000. The legend range of 0-1 indices value on indicates increasing vegetation greenness.

2.5.2 NDVI Application for Estimating End of Season Primary Biomass Production

NDVI data can be applied to estimate primary biomass production for the rangelands. This is a calculation that more accurately estimates herbaceous biomass as opposed to woody biomass. The primary biomass production in 1998 and 2000 is shown in fig 2.5. This data is used to assess land carrying capacity for wildlife and livestock and grazing pressure for different range units. It is a good management tool in drought mitigation.

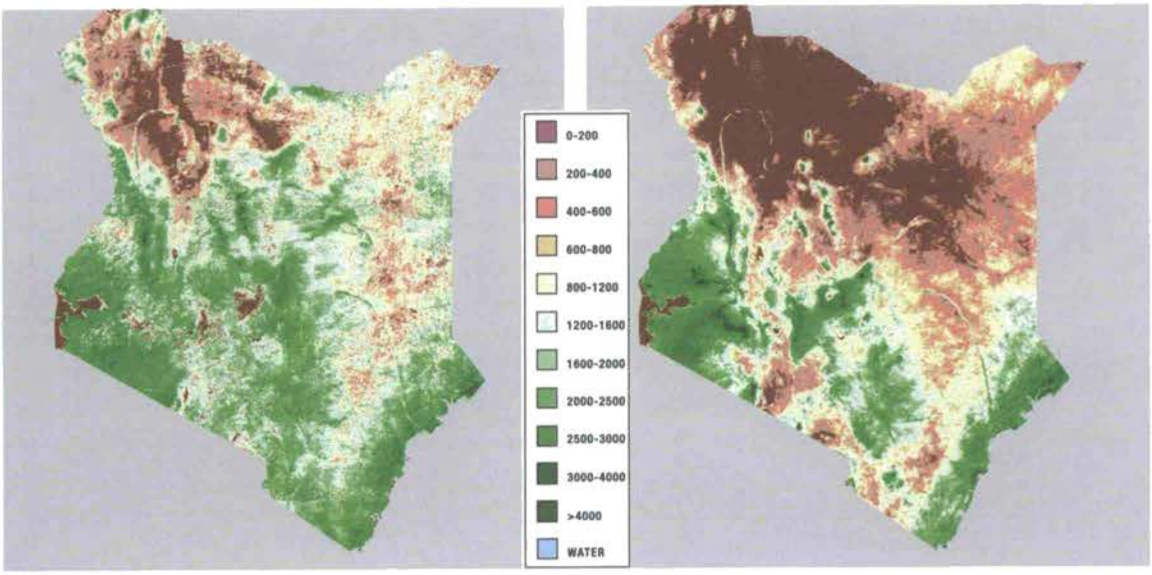


Fig 2.5 Primary biomass production estimates derived from NDVI data in Kg/ha for the long rains in 1998 and 2000 respectively.

2.5.3 Drought Monitoring at District Scale

It is possible to illustrate the effect of the drought at any area of interest. For example, Isiolo district was chosen to illustrate the use of NDVI to monitor the progression of seasons using archival information. This can form the basis of an effective early warning system. Comparisons of satellite data allows the detection of change and provide appropriate threshold value associated with actual change. A series of multi-date imagery can provide information on trends in progression of seasonal development. For example, if a substantive data archive is available, statistical comparison of current events can be made to highlight anomalies in seasonal conditions as illustrated in Figure 2.6.

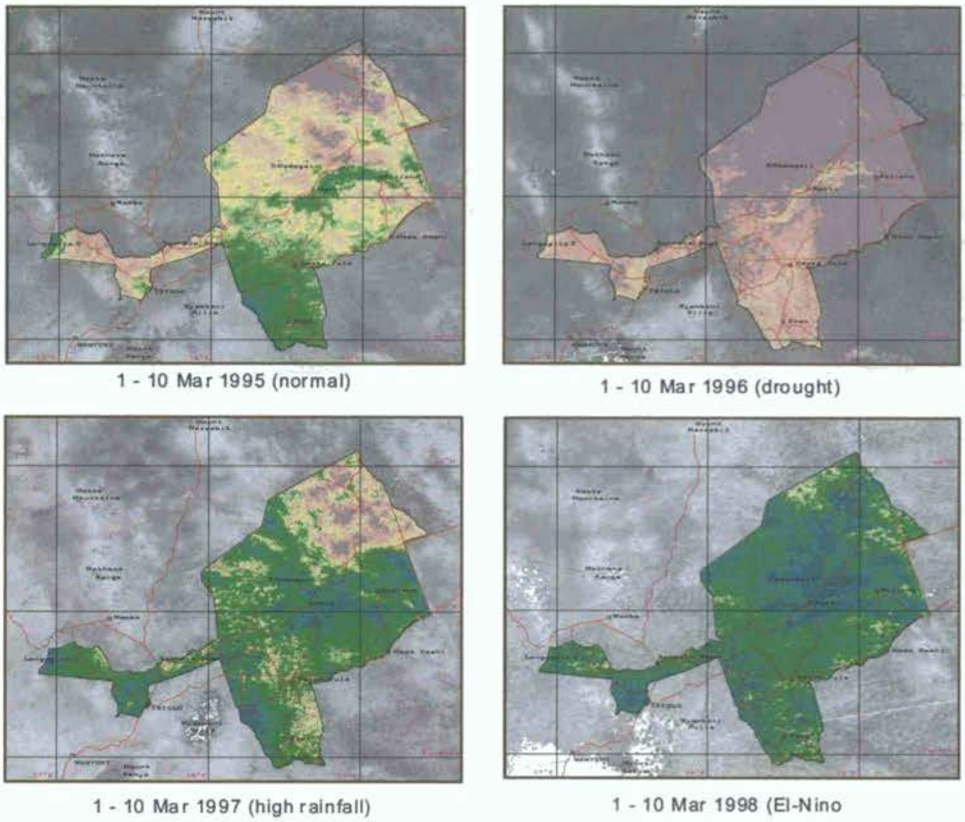


Fig. 2.6 NOAA NDVI images showing rainfall anomalies at the start of long rains (March) between 1995 and 1998 in Isiolo district.

Laikipia, Samburu and Isiolo districts (fig 2.7) form an important northern ASAL ecosystem for both wildlife and livestock depending on availability of pasture and water. Animals normally move southwards towards Laikipia district during drought resulting in conflicts over limited pastures and watering points. In the past, such movements formed part of the coping mechanisms, but with increased settlements and commercial ranches in Laikipia such movements pose a great management challenge.

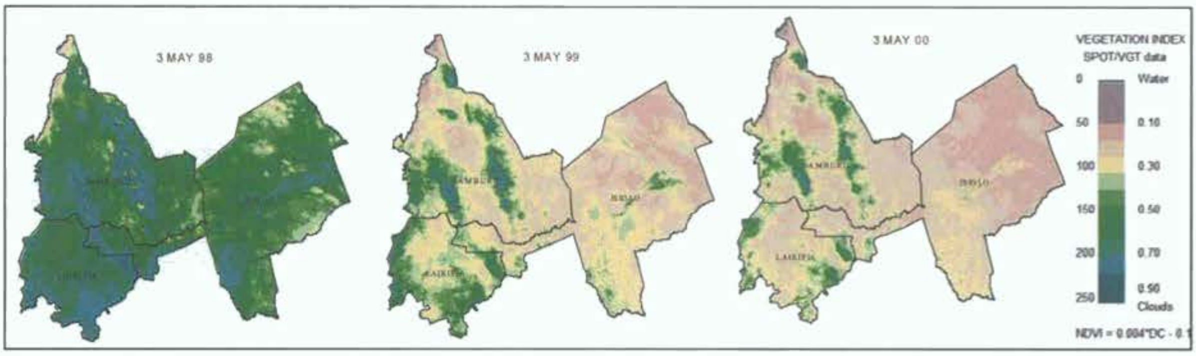


Fig. 2.7 SPOT 4 NDVI images showing rainfall variability over the same period in 1998, 1999 and 2000. The country received the El Nino rains (1997-98) that resulted in heavy flooding, which was followed by one of the worst droughts in 1999-2000. This steep variation in a short span calls for preparedness in mitigating impacts caused by extreme environmental conditions.

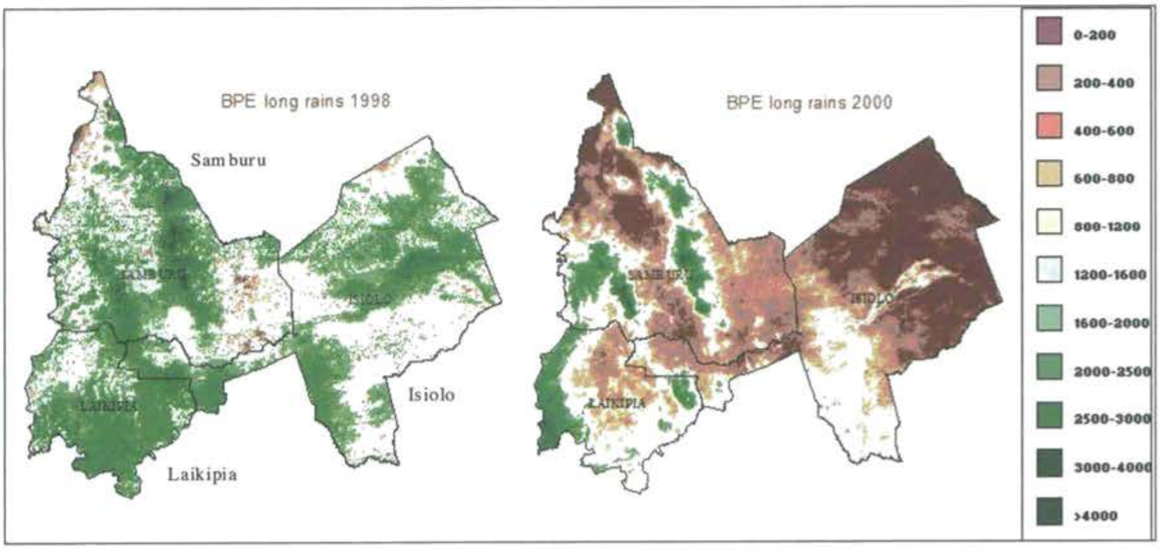


Fig.2.8 Primary biomass production estimates in kg/ha derived from NDVI data for Laikipia, Samburu and Isiolo districts during the El Nino rains and the year 2000 drought.

2.6 Analysis of NDVI Anomalies

The following graphs show the deviation from normal using historical NOAA NDVI data for selected districts in Kenya chosen from the high potential areas, the southern and the northern rangelands during 1982-2004. The representation of the diverse agro ecological zones of the country helps in understanding the impacts in the different zones of the country. Years in which drought was persistent is shown by troughs below normal, which was the zero axis of the NDVI anomalies. The critical drought years in each district are highlighted in gray shade. The droughts in most districts show a cyclic pattern with 1984 reporting drought in most districts followed by minor ones in 1994 and the severest recorded in the year 2000.

The southern rangeland districts of Kajiado and Narok and northern rangeland districts of Isiolo and Laikipia were selected. Aerial surveys were undertaken in the districts to monitor livestock and wildlife populations at the peak of the drought. Nakuru and Murang'a were selected to represent the high potential districts. In the southern rangeland the analysis of the NDVI anomalies revealed a cyclic recurrence of drought episodes from 1982 to 2000. Kajiado district (Figure 2.9) recorded a major drought during the 1982-1984 period. Other droughts in the district occurred in 1992, 1994, 1996 and 1997. The severest drought in the district occurred in 2000 recording the highest NDVI anomaly of more than −2. This result was corroborated from the field report of the district showing 1984 and 2000 drought as the worst in the district in recent years. Although the 2000 drought appears to have been very severe from the NDVI anomalies results, people interviewed perceived 1984 drought to be the worst. This can be partly explained from the fact that 1982-1984 drought was persistent without allowing time for recovery hence the severity of the impacts at the time in the district. The 1999-2000 lasted a short time although recording very high NDVI anomaly.

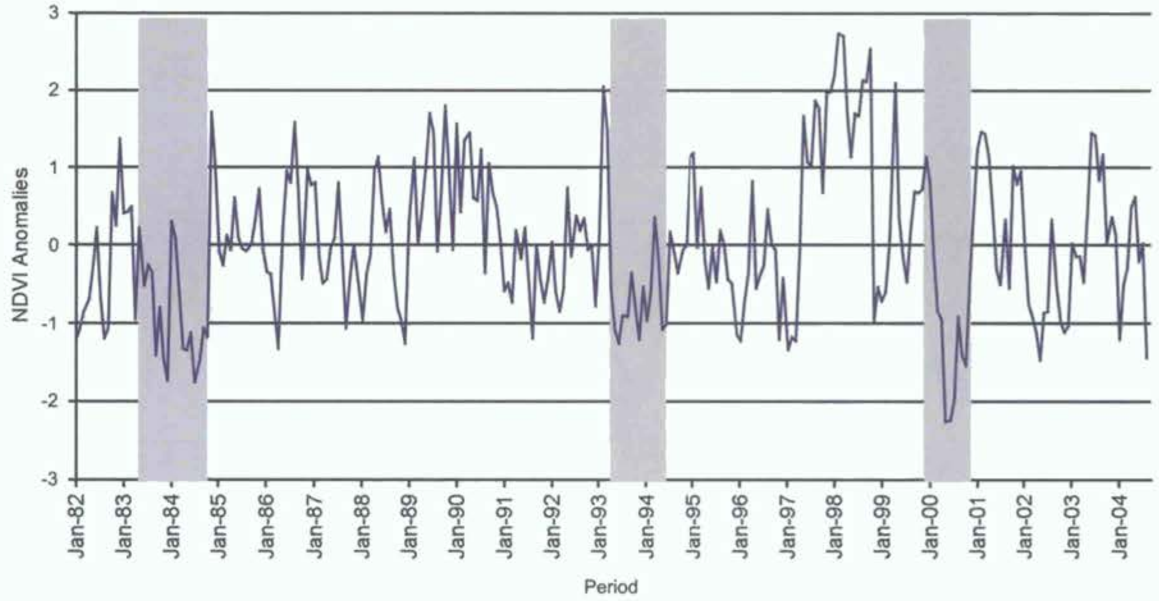


Figure 2.9 Kajiado district recorded the most persist drought in 1983-1985 with devastating effect on the environment.

The NDVI patterns in Narok (Fig. 2.10) slightly follow that of Kajiado although the drought of 1982-1984 was less severe than in Kajiado. The severest drought was during 1999-2000.

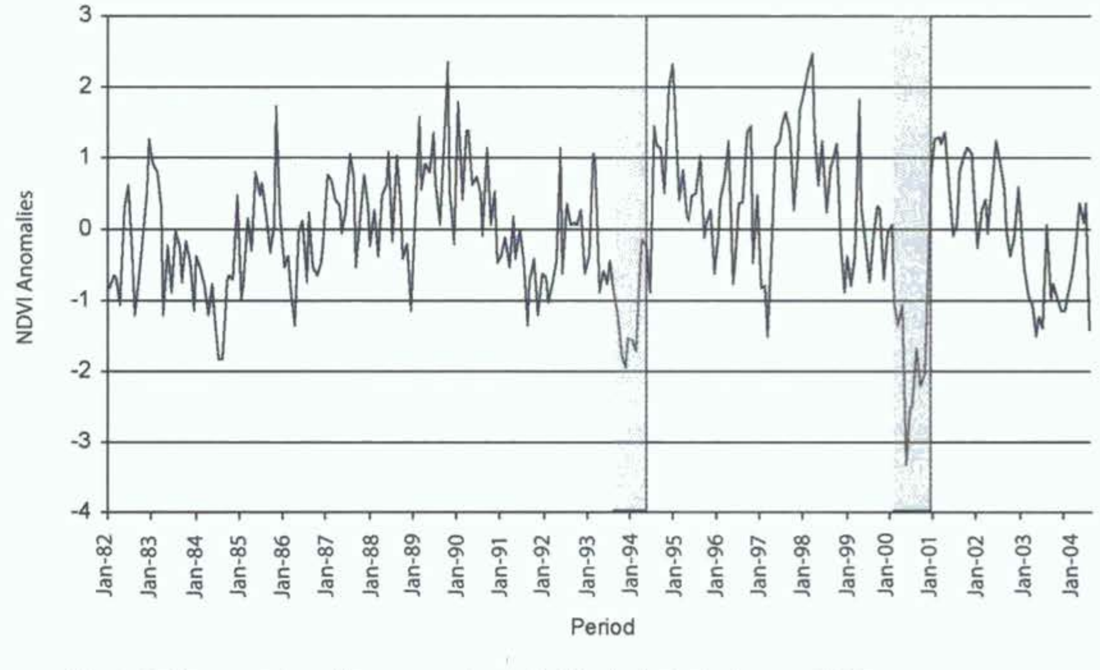


Fig. 2.10 The worst drought was experienced in Narok district in the year 2000.

The drought indices pattern in Laikipia district (Fig. 2.11) show there was a more elongated drought between 1983 and 1986 compared to the drought episode in 2000. The severity of the impacts indicates that coping mechanisms have broken down due to land use changes and land degradation, among other factors. The situation was aggravated by migration of livestock from neighboring districts, increasing competition for forage and water and also resulting in conflicts with farmers and ranchers in Laikipia districts. The NDVI profile shows that drought episodes in Laikipia district occurred in 1984, 1986, 1991-1992, 1994.

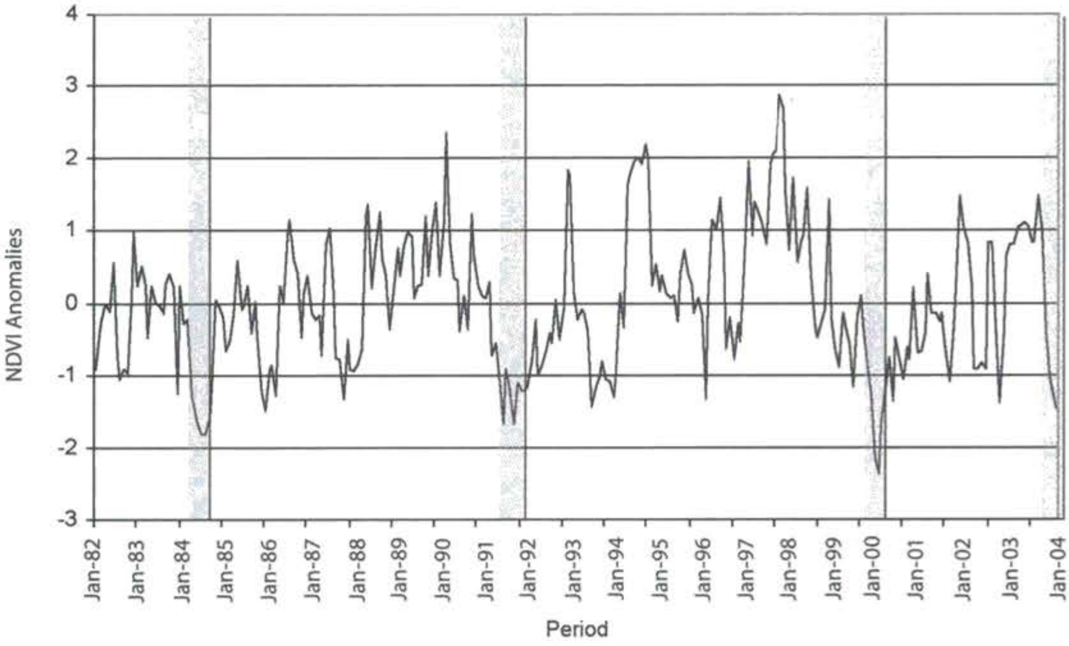


Fig. 2.11 The drought patterns in Laikipia district is similar to that of Isiolo district, although the former experienced mild droughts compared to the later

The Isiolo NDVI pattern (fig. 2.12) indicates that the period between 1991 and 1992 was the worst drought in terms of indices values. The main impact of the drought was on livestock and wildlife. There were also drought occurrences in 1993, 1994, 1996, and 1997.

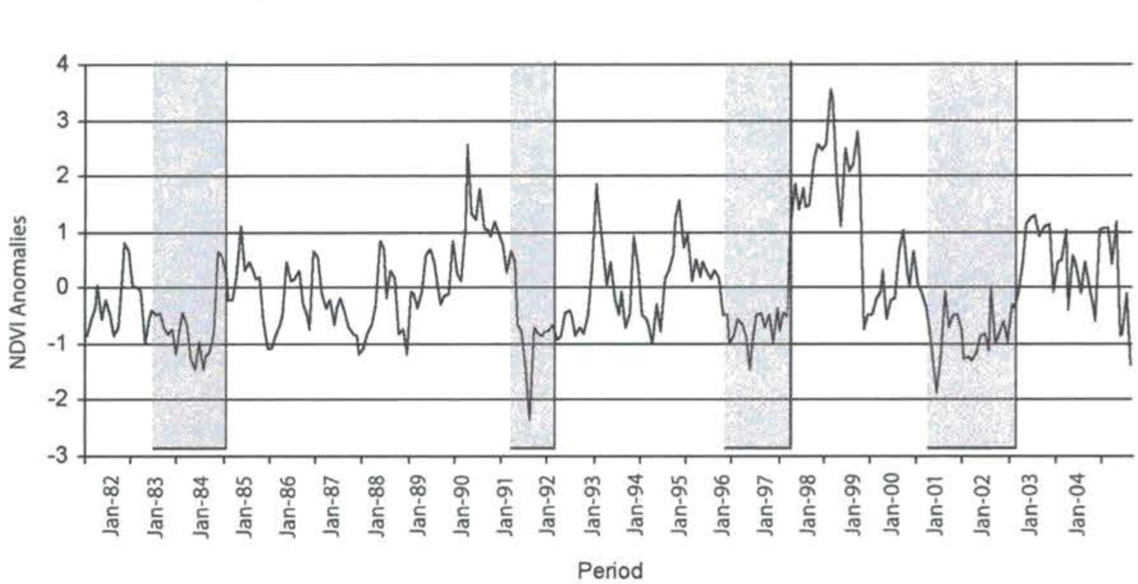


Fig. 2.12 Isiolo district experienced five major droughts between 1982 and 2004.

In the high potential districts of Nakuru (Fig. 2.13) the notable drought episodes occurred in 1984, 1991-1992, 1993-1994 with the severest occurring 1999-2000. This being an agricultural district the effects were devastating on crops.

Murang'a district also recorded a number of drought occurrences with 1983-1985 being very prolonged though the worst drought occurred in 1999-2000 (Fig. 2.14). The district has experienced other minor droughts in 1986, 1992 and 1996. Generally, the high potential areas have increasingly been affected due to other factors such as increased poverty levels occasioned by breakdown of cash crop farming such as coffee and land degradation.

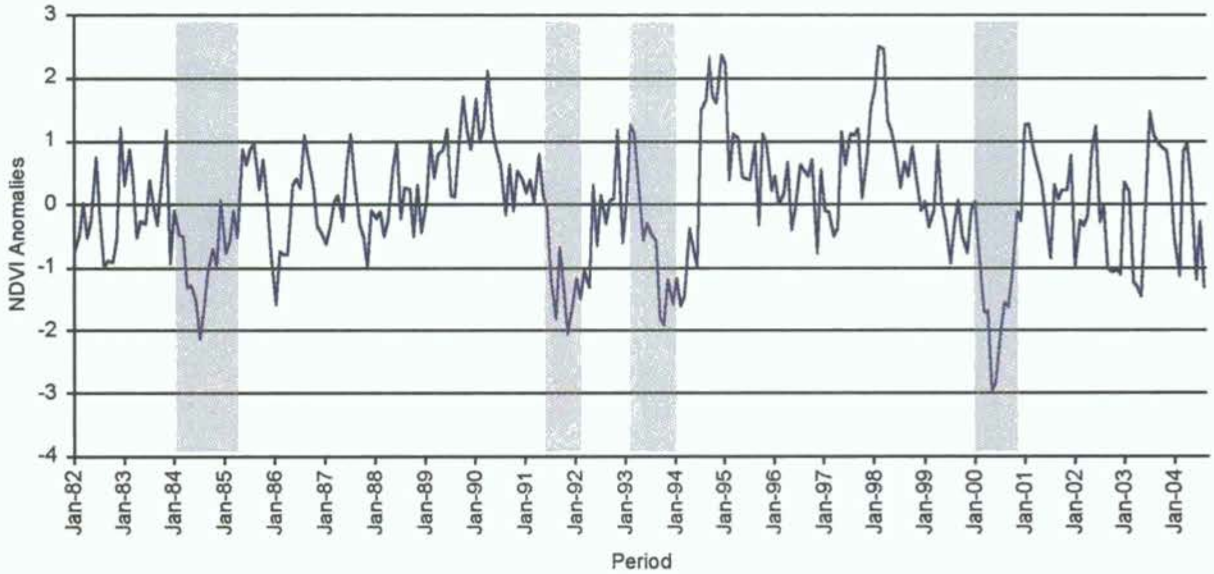


Fig. 2.13 The NDVI anomalies for Nakuru district showing four severe droughts recorded for the district.

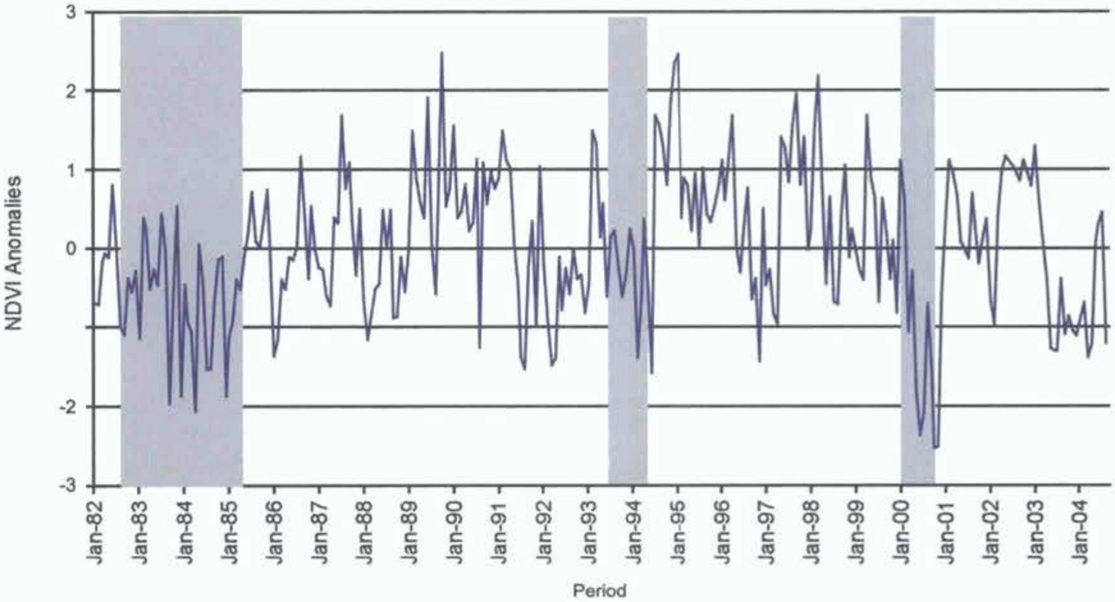


Fig. 2.14 NDVI anomalies for Murang'a district, note the persistent drought recorded in 1982-1985 periods. Yet the impacts of recent drought have been more devastating due other factors.

2.7 Discussion And Recommendations

The results from qualitative and quantitative analysis of NDVI show that it can be used as an effective tool to understand past drought episodes. For example, the 1998, El Niño rains show favorable agro-climatic conditions all over the country including the rangelands. This contrasts sharply with the 2000 drought where the vegetation conditions in most parts of the country were badly affected. The results indicate that the NDVI indices can be used to monitor climatic conditions. NDVI has been proved to correlate with rainfall received although there is a time lag of one to two months (it has been shown that it takes that period for vegetation to respond to rainfall) between rainfall and NDVI received for an area. NDVI has also been used effectively as a proxy to monitor net productivity of various ecosystems. DRSRS has been using NDVI to monitor vegetation condition and primary biomass production in the Kenya rangelands since 1993. This has formed a good database for future monitoring of trends in drought patterns.

The qualitative NDVI products archived for a long period can be used to monitor the progression of a given season. NDVI products for different years (Fig. 2.6) can be used for early warning. By following the progression of a wet season on a decade basis any deviation from normal is easily detected, as was the case in 1996. This drought was occasioned by the failure of long rains in 1996 and was well captured by the NDVI products for that period. NDVI can be supplemented with other information to strengthen the early warning component to mitigate the devastating effects of future droughts.

Vegetation indices from satellite data can be used effectively to monitor drought. NDVI data is available on a continuous basis and can be used in monitoring drought on near real time basis as well as in trend analysis. NDVI data can be applied in both quantitative and qualitative analysis of drought. The data can be used to assess drought duration, intensity and spatial distribution of drought conditions. Satellite data is geo-referenced and can be captured as raster data layer in GIS analysis for use in drought management.

Coordination between institutions dealing with early warning needs to be strengthened; these include The Meteorological Department, Department of Resource Surveys and Remote Sensing, the Drought Monitoring Centre. In addition, the crop-forecasting committee comprising the Ministry of Agriculture, the Department of Resource Surveys and Remote Sensing, and the Office of the President should be reactivated and supported. Finally the linkages between early warning institutions and drought mitigation programmes run by the government and NGO's including WFP should be strengthened.

CHAPTER 3

POPULATION GROWTH AND FOOD SECURITY

3.0 Introduction

DRSRS and the Central Bureau of Statistics (CBS) data were used in this chapter to assess human population trends and food production. The temporal spatial population expansion has led people to migrate into ASALs hence increasing the number of people vulnerable to drought impacts. The results further indicate that whereas the area under crop cultivation has increased significantly over time, crop yields have declined drastically. The results of the analysis indicate considerable geographic variation in the distribution of well being in Kenya. The high potential areas exhibit significant variability of poverty levels. The poverty drought relationship is positively co-related with ASALs having a high number of people affected.

The ASALs were worst hit by drought compared to the high potential areas due to its susceptibility resulting from natural climatic pattern. It was further observed that the number of people affected by drought is on the increase and food security will remain a challenge to the nation. Livelihood systems do not recover adequately 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 than in the past. Rising poverty levels and recurrence of droughts exacerbates this situation.

3.1 The Impacts of 2000 Drought

The 2000 drought was declared a national disaster by the government. In response to the government appeal, WFP spent US$ 102 million on food relief alone (WFP, 2001). In addition, WFP required more than 15,000 tons of fortified blended foods for supplementary feeding programmes in 11 of the worst-hit drought-affected districts located in pastoral, agro-pastoral and marginal agricultural areas of the Rift Valley, North Eastern, Eastern and Coast provinces. On its part, the Government spent in excess of KShs 10.5 billion on relief food to combat the drought emergency during the 2000-2001 financial years. Imbamba (2004), reported that the La Niña drought (1999-2001) cost at least KShs. 220 billion compared to the El Niño floods which cost the country approximately KShs 70 billion. The year 2000 drought was the worst in 40 years.

3.2 Human Population

The high growth rate recorded for 1948–1962 for Kenya was due to the improved completeness of the census, but there is no reason to doubt the rapid expansion of the population recorded from 1962 onward (Table 3.1).

Table 3.1. Population size and growth rates

	Population (thousands)			Growth Rate (%)
Census Year	Males	Females	Total	
1948	2,680	2,726	5,406	-
1962	4,277	4,359	8,636	3.34
1969	5,482	5,460	10,943	3.38
1979	7,607	7,720	15,327	3.37
1989	10,628	10,815	21,443	3.34
1999	14,206	14,481	28,687	2.90

Source: CBS, 2001

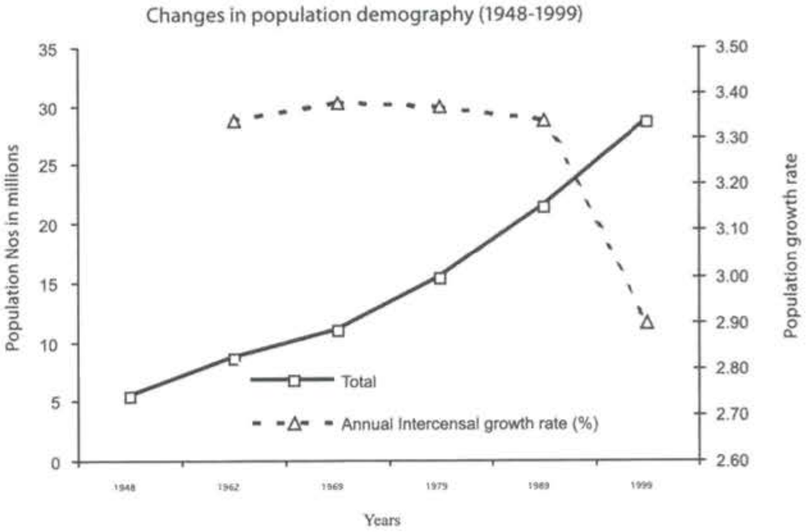


Figure 3.1: Changes in human population demography in Kenya between 1948 and 1999. *Source: CBS, 2001*

Figure 3.1 presents the underlying demographic changes of human population numbers compared to inter-census population growth rates at the national level from 1948 to 1999. There is a rising trend in the rate of population growth from the 1940s reaching a peak in the 1970s and a gradual decline thereafter. The first indications of a rising trend in population growth in the 1960s undoubtedly helped spur the adoption of a national population policy and programme in 1972. Similarly, the later estimates of natural increase as high as 3.38 percent led to a renewed effort culminating in the creation of the National Council on Population and Development, and numerous new initiatives in the 1980s. This has led to the drastic drop in population growth rate.

3.2.1 Drought and Human Population

In 2000, Kenya suffered the third serious drought in ten years, with the ASAL being the worst affected. During each succeeding drought, the number of people requiring emergency assistance has drastically increased. The government estimated that 4.7 million people in 32 districts required assistance in 2000 drought. However, the World Food Programme assisted 3.3 million people affected by drought (WFP, 2001). About 25-30% of children under 5 were estimated to be severely malnourished due to food scarcity during the drought in ASALs (Save Children, 2000). WFP further observed that even if the drought situation subsided, families still needed assistance into 2001 to enable them restore their livelihoods.

Kenya's population has more than tripled in the last three decades. The population has not only increased in absolute numbers but also spatially (Figure 3.1). Situma (2003) reported that spatial human population has up-surged in agro-ecological zone IV and V. Migration from more densely populated high-potential areas puts extra pressure on existing limited resources in the ASALs. According to the 1999 human population census report, an estimated 12 million people now live in the ASALs districts compared to 8 million a decade earlier. This constitutes about 36% of the country's population. Of these, an estimated 20% live in the arid districts. The density of the population varies (Figure 3.2). Significant changes are taking place over time, most notably in districts that are 50-85% ASALs. This is mainly due to immigration. For example, Machakos district's population density has increased over the last 20 years from 0-50 persons/km^2 to an estimated 101-200 persons/km^2. This has implications on population's resilience to drought impacts; the severity of drought impacts is increasing over time. Increased population density over the years has led to land degradation, making it less productive and more susceptible to impacts from extreme weather events.

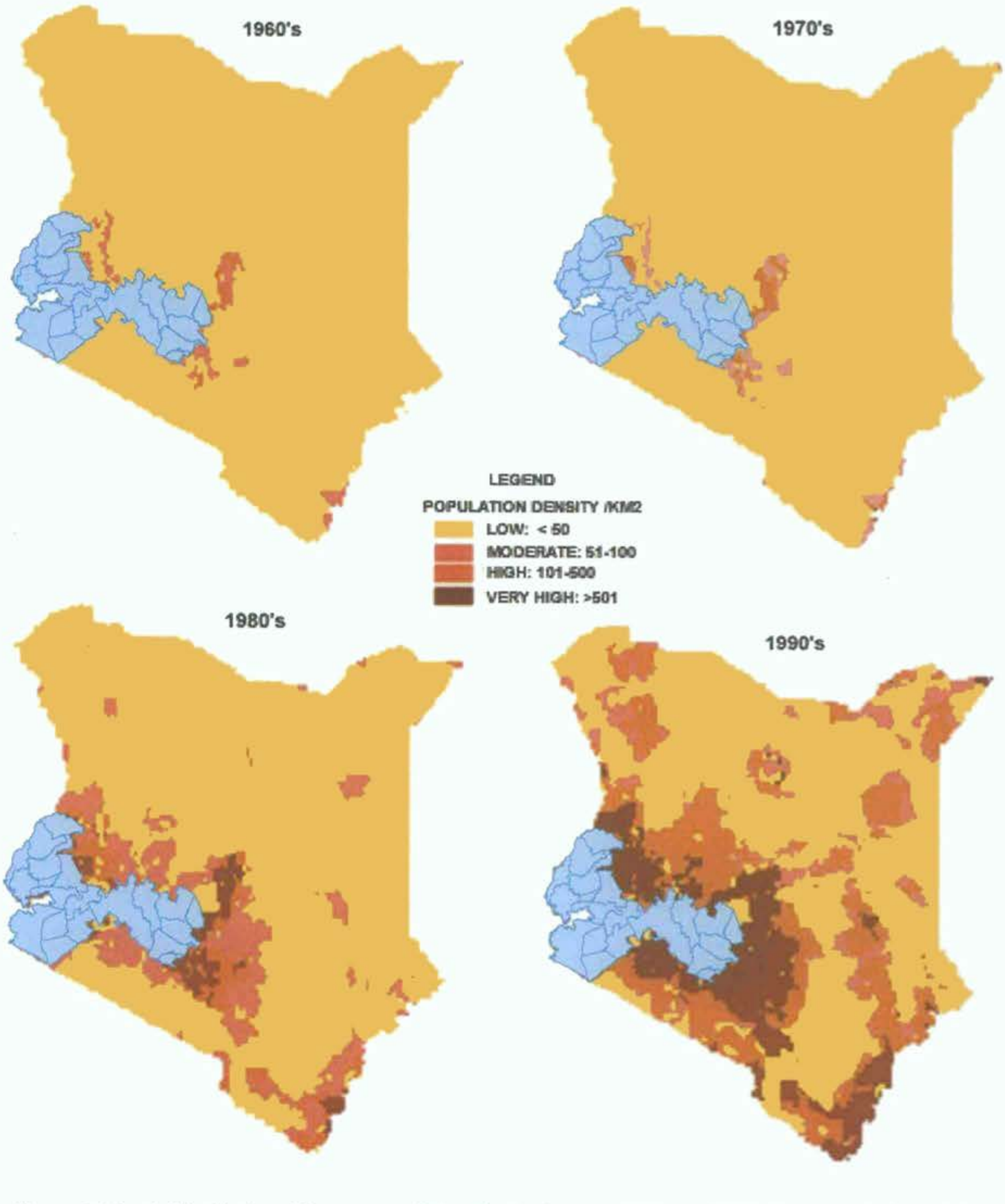


Figure 3.2 Spatial distribution of human population density between 1960s and 1990s. The spread of population from the high potential areas (blue color) into the ASAL areas has caused high environmental degradation (*Source: CBS, 2001 & Population Census*)

3.2.2 Population expansion in the ASAL areas

The distribution of Kenya's human population is to a large extent limited by geo-biophysical characteristics, such as climate conditions, freshwater availability, infrastructure and urbanization. The human population and associated economic development have been increasing rapidly since 1960. Large areas, which were previously unsettled natural land, have since been encroached by large human population and agricultural activities, which may not only lead to severe land degradation, but also to the loss of large animal numbers and vegetation.

Rapid population growth in 1970s resulted in disproportionate rural-urban migration. Over-concentration of services and administrative functions in the urban centers attracted people in search of better livelihood opportunities. There was limited opening up of natural landscapes for farming and therefore less land degradation. The high population pressure in the high potential areas led to the migration of people into the medium and low potential areas of Kenya. The nucleus settlements, previously, limited to different cultural values, political inclination, and economic systems were disregarded. Accordingly, by 1990's the distribution of people was widely spread in the country, with high potential areas and urban centers densely populated.

3.2.3 Human activity and drought

Human population in the arid, semi-arid and dry sub-humid areas is affected by poverty, thinly scattered and with minimal means of ground communication. Information on drought impacts often reaches the authority too late when the damage is already done. Interventions are equally difficult to undertake to save lives. The survival of most people is therefore dependent on weather patterns during the cropping seasons, cultivated area and inputs. With the rapid increase of population, these subsistence farmers continue to open more land for cultivation of crops, thus exposing the soils to weather elements, over exploitation and eventual degradation. Extended severe droughts normally leave populations hungry and poorer having lost livestock and crops and disrupted livelihood systems. This reinforces their poverty, which means they cannot purchase and use optimal agricultural inputs in the next season so as to increase productivity. This leads to increased poverty and the opening of more land for cultivation. These trends need to be monitored: trends in absolute cultivated area and geographical spread. Pastoralism is also still widespread in many parts of the Kenya rangeland. Probably this is the oldest land use system still persistent. When the range was still expansive, nomadism as a survival strategy in time of drought, used to save the stock. However, livestock movements in search of pasture are much more restricted now. The pastoralists have therefore become more vulnerable to droughts than before. The traditional dry season critical resource zones have been lost to sedentary communities who depend on rainfed agriculture.

There have been high population growth rates and densities in the dry sub-humid areas as a result of migrants. They more often than not put their new settlements under environmental stress and therefore under the mercy of the climatic condition of these zones. Refugee influx coupled with human population encroachments into the fragile dry lands that has low resilience are major concerns to resource managers, especially in respect to the survival of mankind in the long-term. At the same time, environmental refugees especially due to several droughts in arid and semi-arid zones also make the dry sub-humid zones vulnerable to degradation. Traditional drought and famine coping strategies are rapidly being lost.

3.2.4 Poverty Prevalence

Levels of poverty have been growing in most parts of the country for various reasons; low economic growth, high unemployment rates, and breakdown of cash crop in the high potential areas such as coffee farming. This partly explains why drought impacts are becoming more severe, high potential areas that were in the past mildly impacted by drought were particularly affected by the 2000 drought because of increased poverty. In the ASAL areas, livestock marketing infrastructure is inadequate. It was observed during interviews that pastoralists are now more willing to sell their herds during drought. Proper marketing infrastructure will improve their economy and enable them to cope with the impacts of drought. In Kajiado district, it was noted that cattle prices were one tenth of the normal prices during the drought and this left the pastoralists poorer than they would be if proper marketing were in place.

There is considerable geographic variation in the distribution of well being in Kenya. Areas in the high potential zones exhibit significant variability of poverty levels (Figure 3.3). ASAL districts show less spatial heterogeneity in poverty levels. Poverty densities are also scattered indiscriminately across the country. An overlay of spatial data of poverty density and drought vulnerability indicates that 85% of the people in ASAL are susceptible to drought impacts. Some areas are endemic to poverty as well as drought.

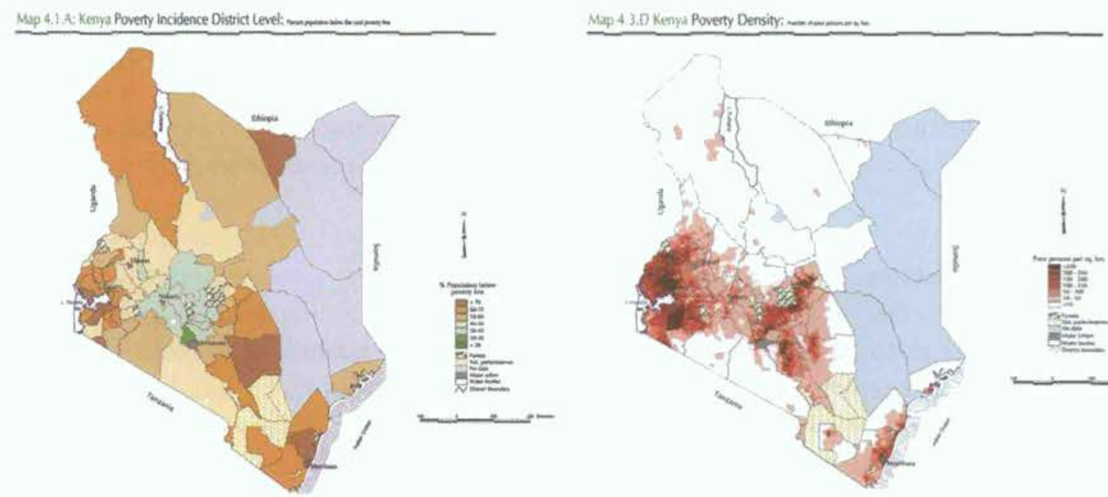


Figure 3.3: Poverty analysis in Kenya. Proportion of population below the rural poverty line (left), and poverty density (persons per Km^2) (right): *Source: CBS/ILRI, poverty mapping*

3.3 Agriculture

Droughts have a direct impact on food security. The most important cereal crops in Kenya are maize, wheat and to a lesser extent rice. The others include legumes, sorghum and millet. However, the latter are nationally insignificant in terms of production and consumption levels. Maize and wheat are the staple food crops and are produced in the agriculturally high potential areas (which comprise about 18% of the country's land area) under rainfed farming systems while rice is mostly produced under irrigation. The grains reach all consumers in the country from surplus producing areas to deficit areas through distribution networks.

Guarantee of production and/or availability of the two staple foods to the consumers are a major responsibility of the Government. However, the final level or net production is subject to various factors including:

- Area put under the crop by farmers
- Prevailing weather and climate
- Soil fertility and water holding capacity
- Type of farming system
- Availability of inputs and their costs
- Cost of labour, land preparation implements, fertilizers, certified seeds, pesticides, herbicides, etc.
- Pre-harvest and post-harvest losses.
- Market forces

3.3.1 Maize and Wheat Crop Forecasting

The Department of Resource Surveys and Remote Sensing (DRSRS) has developed an elaborate method of forecasting the production of wheat and maize crops. The programme estimates area planted with maize and wheat, as well as estimated crop yield. The eventual outcome is crop production. Estimating demand and consumption of these crops is an important aspect of monitoring food security. Information on national food security status is necessary in the light of the Government's long-term policy of self-sufficiency in feeding its people and maintenance of strategic reserves. Area planted is estimated using sample vertical aerial photographs taken along regularly spaced transects. Yield requires assessing of the healthiness of the green crop biomass in the field using airborne radiometers. The biomass measurements are then converted into yields through a field derived relational formula (Peden and Mwendwa, 1984). The estimated area under the crop and the estimated yield for any area are used to forecast total crop production (biological production or yield). The accumulated annual statistical information on these crop forecasts has become an important component of the national data bank, which can be used, in strategic planning. This data bank has previously been used effectively in national food crisis management and the preparation of long term strategic plans. The quality and validity of these data are of paramount importance and must be maintained in order to achieve the objectives of the programme i.e. crop forecasting and creating an accurate database for national food security planning.

Due to the large area which is covered, multi-stage sampling techniques using satellite remote sensing, systematic reconnaissance flights, and small format photographs and ground sampling are used to determine the cultivation or the maize growing stratum in the country. The techniques used often complement each other, no single technique is wholly used. Usually an area with 10% - 15% would determine the cultivation boundary, (Pilotto, 1988). The procedures used include: satellite images, reconnaissance flights, and vertical aerial photographs (Ottichilo and Sinange, 1987, 1988, 1990 and 1991).

3.3.2 Historical Trends in Maize Production

Crop data analysis shows that trends in area under maize has fluctuated between 0.87 million ha and1.4 million ha (Figure 3.5). In a given season, the area cultivated is dependent upon family subsistence needs, economic opportunities perceived and weather characteristics. Farmer's always plant maize crop each year regardless of risks anticipated, since it's their staple food. Thus, there is insignificant difference in area under crop over the years including drought periods. The gradual increase in area under crop is due to expansion of agriculture in ASAL areas as well as along

Fig. 3.4 Encroachments by agricultural in the drier parts of Kajiado district.
Photo by A. Odour (RELMA in ICRAF)

riverbanks and other wetlands (Figure 3.4).

Maize production has fluctuated over the years (Figure 3.6). Deficits were experienced in 1987 and all the years after 1989. The deficits are attributed to unfavorable weather (unpredictable rainfall) over the years, losses due to drought, reducing soil fertility particularly in high potential areas and poor agronomic practices often due to increased poverty levels. Other factors include limited access to inputs especially fertilizer and certified seed; poor harvesting and storage practices; unproductive cultural practices and pre-harvest and post harvest losses.

The prospects of crop failure have been high in most parts of the country due to the onset of drought before crop maturity. The country attained the lowest possible level of production in 1994 since 1989 due to prolonged drought. It was also probably because of reduction in area under maize in the long rains season. The impact of dry spell of the 1993 was severely felt in 1994. Food deficits experienced in 1996-97 (Figure 3.6), were due to failure of the short rains. It was estimated by FEWSNET (1997) that the failure of rains during the short rain season contributed a 32% deficit on a national scale. In 1996-97, GOK declared a shortfall of approximately 8.5 million 90kg bags (761000 MT) maize prompting emergency plans for food importation, increased coverage of relief distribution and waiving duties on all relief food stuffs.

The average annual net maize production in the 1990s was 26 million bags (2.31 million MT) while maize consumption was 29 million bags (2.65 million MT). The national population then was 27 million with a mean consumption rate of 1.2 bags (100kg) per person per year (DRSRS database; FEWS, 1997). Thus consumption has been increasing due to increase in population. Following the liberalization of the agricultural crop markets, the purchase of food crops by the National Cereal and Produce Board (NCPB) has fallen drastically. Maize farmers prefer to sell their crop to private companies or individuals who pay on delivery as opposed to delayed payment by NCPB.

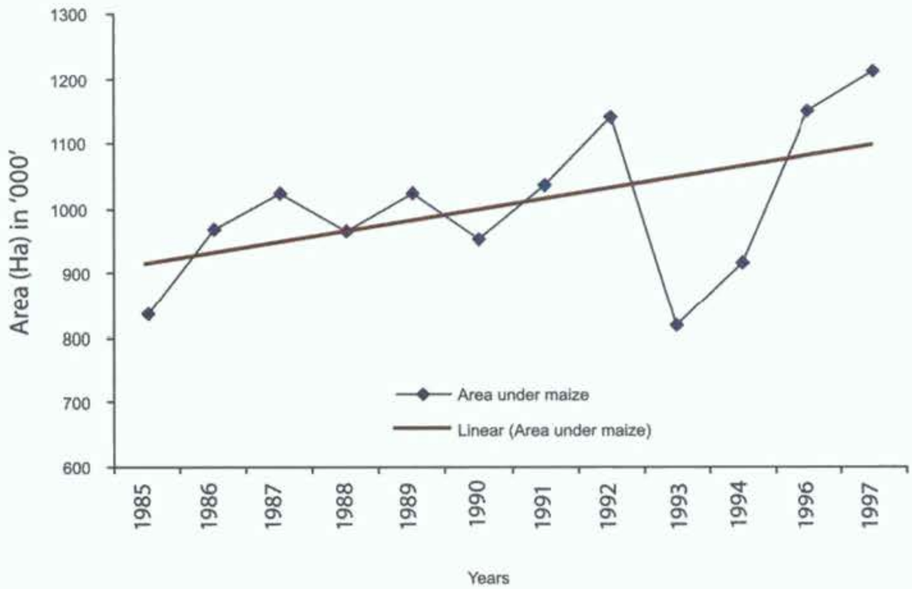


Figure 3.5. Trends in area under maize in the country from 1985 to 1997 *Source: DRSRS database*

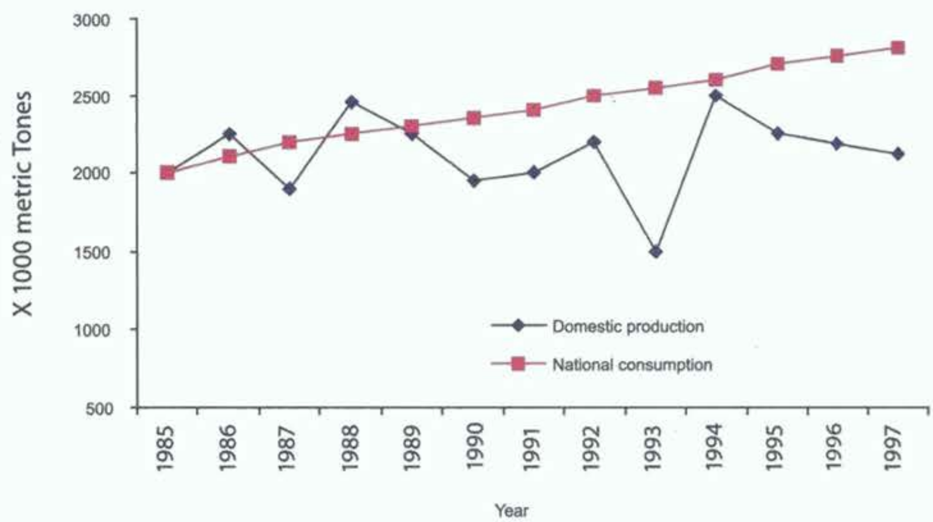


Figure 3.6 Trends in per capita Maize production and consumption
* Assuming consumption of 98 Kg/capita/year *Source: DRSRS*

3.4 Expansion of Agriculture in Drought Vulnerable Areas

Expansion of agriculture from 1970s to 1990s is shown in figure 3.7. Agriculture expanded largely into more vulnerable ASAL areas. The largest change in observed frequency of agriculture expansion occurred in Narok, Machakos, Makueni, Kitui, Kajiado, Laikipia and West Pokot districts.

Moderate change in observed frequency of agriculture expansion occurred in Baringo, Taita Taveta, Kwale, Kilifi, Tana River and Samburu districts (zones 4 and 5). Limited changes in observed frequency of agriculture expansion occurred in Marsabit, Moyale, Isiolo, Lamu and parts of Garissa (zone 6). Most of the agricultural activities occurred in the dry sub-humid zone and semi-arid zones. In recent times, agricultural activities are spatially encroaching into semi-arid landscapes, but minimal activity was observed in arid areas. The proportion of land occupied by agriculture increased tremendously between 1970s and 1990s (figure 3.8). These ASAL areas are traditionally grazing areas for both wildlife and livestock. As migrants moved into the vulnerable areas, they naturally settled on the wetter places, around water sources, swamps etc which are vital locations for pastoralists during drought.

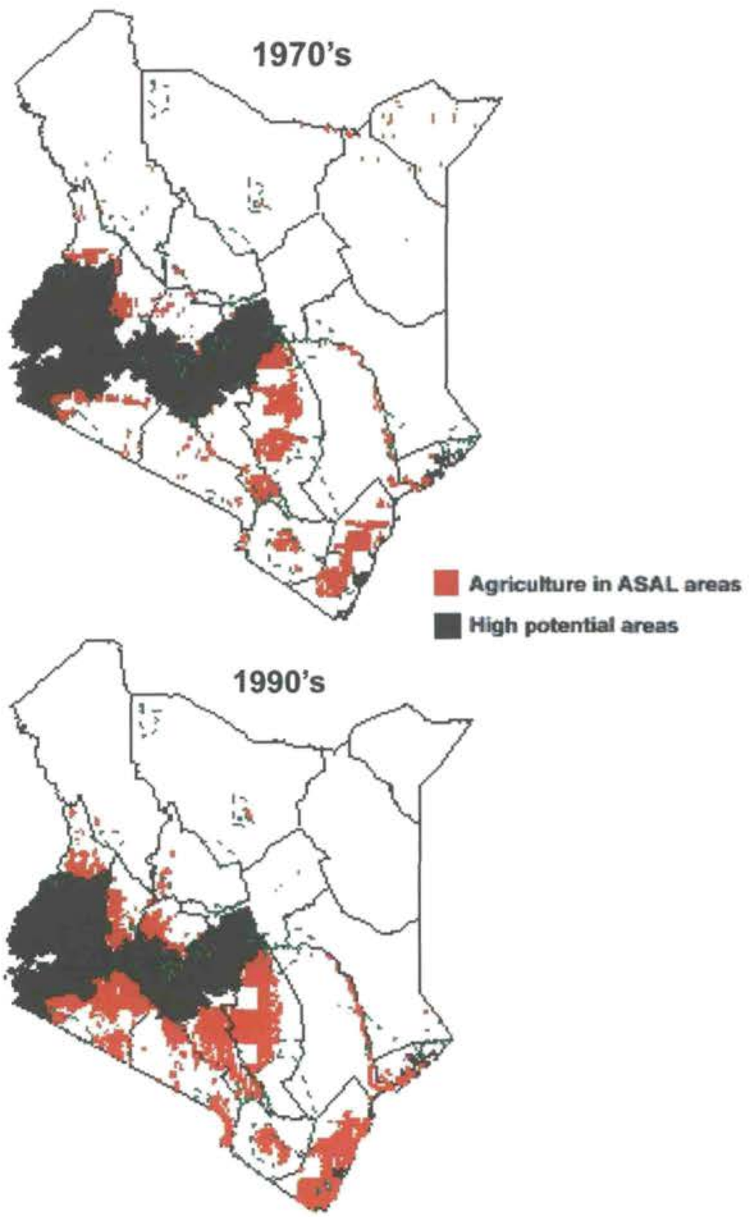


Figure 3.7. Expansion of agriculture in ASALs, which includes the vulnerable areas between 1970s and 1990s. Source: Composite point maps from DRSRS aerial surveys data.

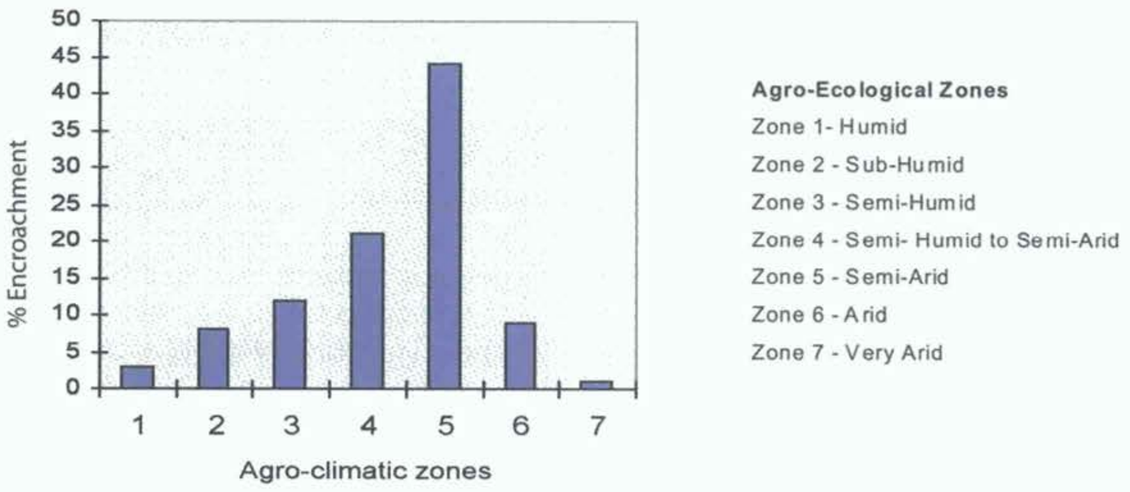


Figure 3.8 Expansion of agriculture in the seven agro-ecological zones between the 1970s and 1990s. ASAL areas have had the larger proportion of agricultural expansion resulting in destruction of ecosystems. *Source DRSRS*

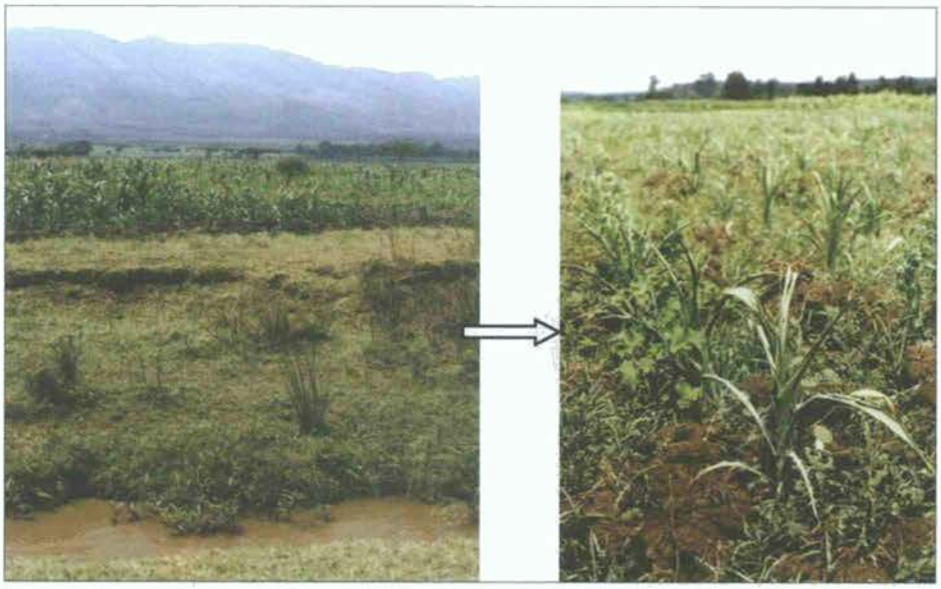


Fig. 3.9 Wilted maize crop in Baringo district, 2000. Farmers had crop failure in three consecutive years but were still hopeful of a harvest this time. Use of stream water for irrigation had been banned due to water scarcity.

As the limited amount of water is diverted for irrigation (Fig.3.9) in ASAL areas, it becomes more difficult for pastoralists to withstand drought impacts. Expansion of agriculture into ASAL areas is also causing destruction of vital ecosystems (Fig. 3.10), while this cultivation is eventually not sustainable. These factors have lead to increased land degradation making drought impacts more severe on the local residents. Such land use activities need to be addressed at policy level when addressing drought impacts and its management.

3.5 Agriculture in Narok district (case study)

Narok is one of the districts that have experienced an influx of human population from high potential areas and a large expansion of agriculture in the recent past. In addition, the conversion of large areas of land formerly used by wildlife and pastoral livestock into large-scale wheat farms has exacerbated human wildlife conflicts and affected food production. Elephants in particular have increasingly become a menace to subsistence farmers.

Fig. 3.10 Wetlands in Baringo district, which were traditionally used for dry season grazing by pastoralists, are gradually encroached by agricultural activity.

The factors that are responsible for the low crop production in Narok include poor cultivation techniques, lack of credit facilities and market outlets. However drought and crop damage by wildlife remain the main constraints to rainfed cultivation. Droughts account for over 20% of crops lost before maturity, whereas crop damage by wildlife accounts for 10% of the

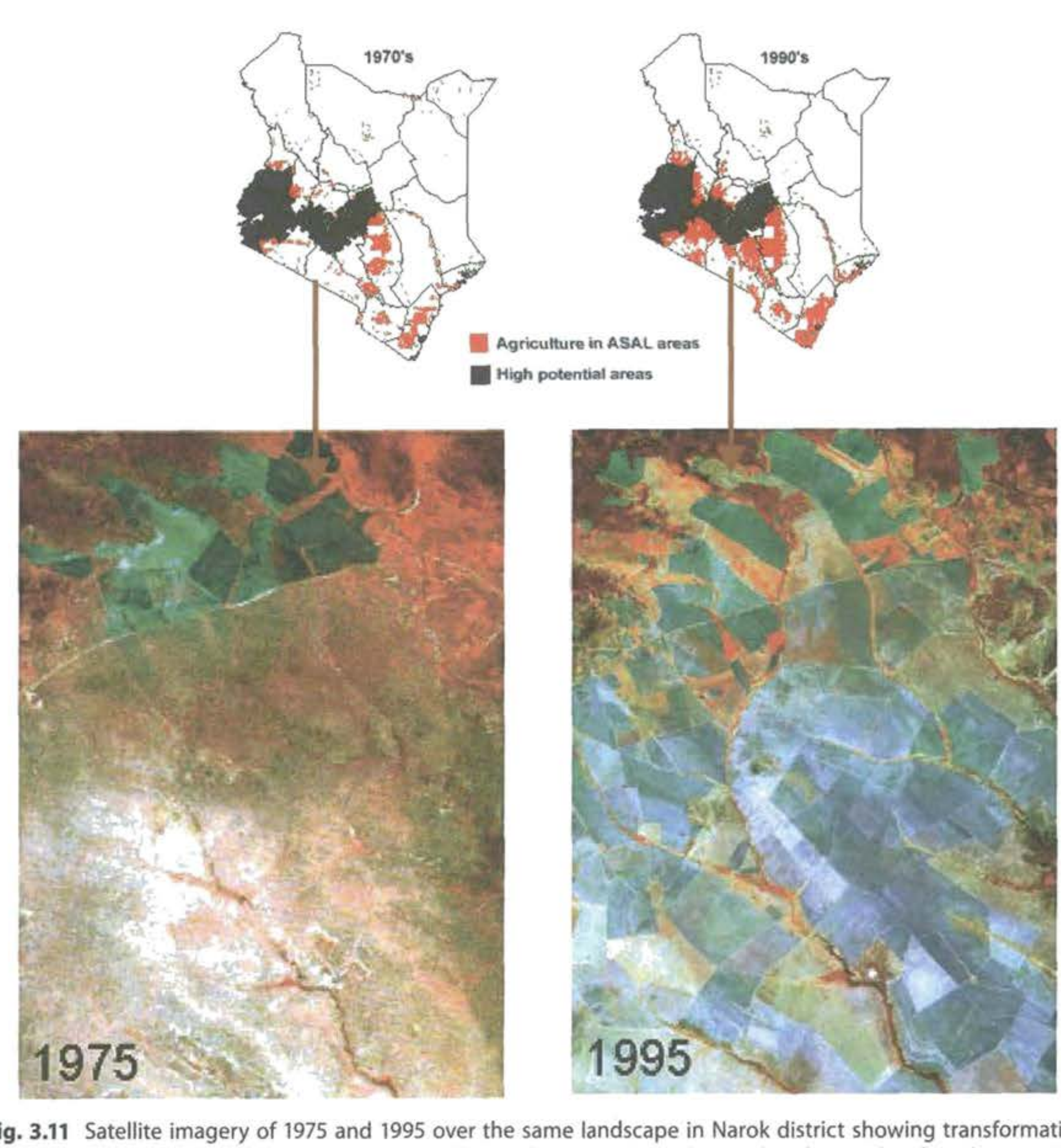


Fig. 3.11 Satellite imagery of 1975 and 1995 over the same landscape in Narok district showing transformation of wildlife/ livestock grazing areas into wheat farms. The expansion of agricultural areas has largely remained commercial and is of little benefit to the locals. Crop destruction caused by displaced wildlife from their former range has increased food insecurity in these areas.

total production (DAO, Narok). Crop damage by grazing livestock, destruction of seeds by birds (mainly the quelea birds (*Quelea quelea aethiopica*), Russian aphids (mainly prevalent during drought periods) and other crop pests also significantly accounts for the massive loss in crop production.

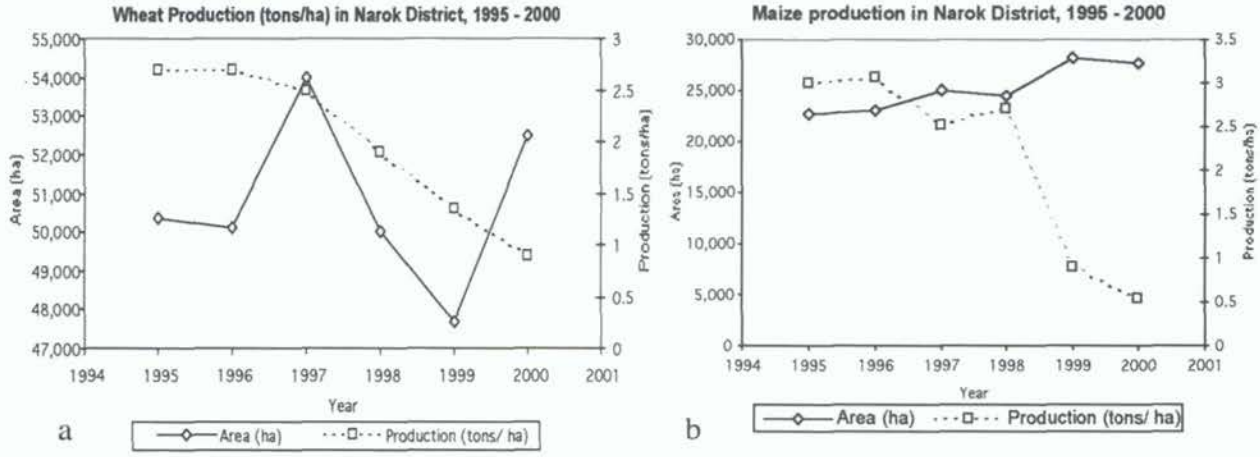


Figure 3.12: (a) Wheat and (b) Maize Production in Narok District between 1995 and 2000. *Source: DAO, Narok.*

Wheat occupies more than 50,000ha in Narok district and accounts for nearly 50% of the country's total production. The production of wheat declined from 2.7 tons/ha in 1995 to 0.9 tons/ha in 2000 (Fig. 3.12a). Although the area under the crop increased significantly from 50,000ha to 54,000ha in 1997 (mainly due to the El-Nino rains), the production declined steadily, probably due to destruction by the high rains and crop damage by wildlife. The impact of the El Niño resulted in the reduction of the wheat fields to less than 47,500ha in 1999. More than 25 million quelea birds (*Quelea quelea aethiopica*) invaded the fields in 1998 causing a loss of nearly 10,000ha of cropland. The area under the crop was increased significantly by 2000 in

Figure 3.13 Preparation of large-scale wheat farm in Narok district. Expansion of agricultural areas in the rangelands occur at alarming rate despite the effects of droughts on crop yields.

Fig. 3.14 Success in wheat farming in Narok catalyzed land use change. However, production fell from 2.7 tons/ha in 1995 to 0.9 tons/ha in 2000.

Fig. 3.15 Settlement near Amboseli National Park has led to widespread human wildlife conflicts.

anticipating of the rains, but yield declined to its lowest (< 10 tons/ha). The low yields were attributed mainly to the effects of drought and partly to damage by wildlife and livestock.

Maize is a subsistence crop. However, excess maize is often sold for cash in the local markets or to the National Cereal and Produce Board. After the El Niño in 1997, the area under crop production increased to more than 23,000 ha. However, yield fell from 3 tons/ha to 0.5 tons/ha in 2000, the lowest since 1995. The low maize yield is again attributed to the drought, but grazing livestock and wildlife damage also played a role. The maize deficit was partly supplemented by the huge donor assistance in the form of relief food aid during the drought. Declining levels of crop production have been a major factor in the severity of drought impacts.

3.6 Food security

A fundamental element in the assessment of risk is the evaluation of vulnerability. Vulnerability is used to describe the relative susceptibility of households to various levels of food insecurity (FEWS 1993). Vulnerability assessment examines the degree to which a population or region is susceptible to a range of hazards, in this case drought, that threaten food supplies, and for which food assistance is required. If one has the ability to protect against the effects of drought, or to offset its impacts, then the risk posed by that hazard is correspondingly reduced. FEWSNET used a number of factors to map food security zones. These are: crop risk; market access; coping strategies; drought risk; and physical insecurity.

Coping mechanisms whether traditional or highly conventional assists in subduing drought impacts. Irrigation practices in areas where water can be harnessed or harvested is a useful drought coping mechanism (Figure 3.16)

Figure 3.16 Irrigation is practiced as a drought coping mechanism in spite of water scarcity.
Photo by A. Odour (RELMA in ICRAF)

Figure 3.17 Distribution of relief food (maize) to the victim.
Photo by P.Smerdon (WFP)

The trends in number of people affected by drought have continuously increased generally over the past years (Figure 3.17 and 3.18). The highest number of those affected by drought was recorded in 1992 and 2000.

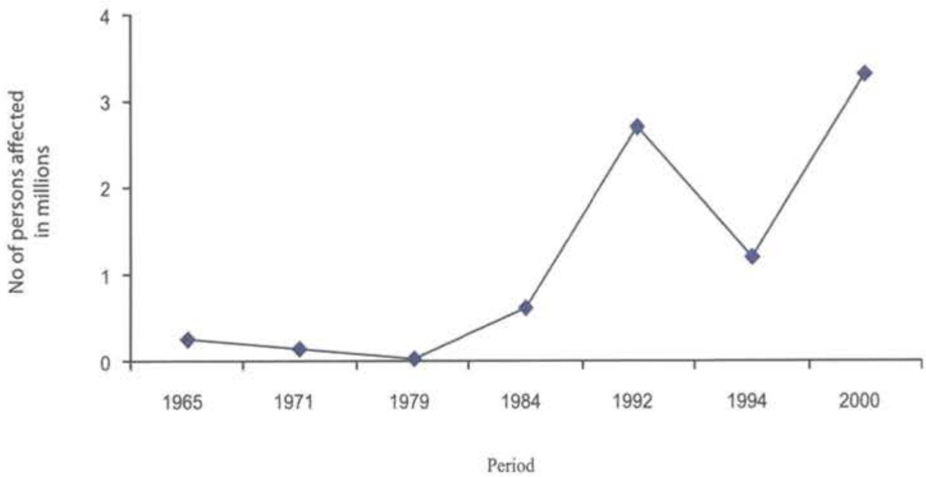


Figure 3.18 The number of persons affected by drought has been rising between 1965-2000. *Source: WFP, Nairobi.*

Emphasis is placed on how government policies, backed up by technologies to aid drought prediction, monitoring, and management, are expected to lead to more self-reliant management at the farm level, and the development of agricultural systems that are physically, biologically, and financially sustainable. The pressure of the increasing population will push desperate subsistence farmers further into the arid lands where sparse rains are more variable and less reliable. In such locations the very process of land clearance is likely to increase vulnerability of the area to drought as protective deep-rooted vegetation is removed.

3.7 Conclusion and Recommendations

The ASAL were worst hit by the 2000 drought compared to the high potential areas due their vulnerability. The number of persons affected by the impact of drought has continued to rise over the years. The upward trend in human population increase has led to the influx of people into ASAL in search of land. These areas have shown high vulnerability implying more and more people will continue to be affected by drought. Crop yields as well as crop production has showed a downward trend, especially during prolonged dry spells. Therefore food security will continue to remain a challenge.

The government should start to address urgently the destruction of ecosystems that have traditionally been used in drought coping mechanisms. Most of these are being converted into agricultural land. It is also imperative that Strategic Environmental Assessment (SEA) is done on major land use changes such as the introduction of large mechanized farming including flower farms that are mushrooming in ASAL areas.

There is need for more detailed studies on the links between drought severity and factors such as land use practices, land degradation and forest destruction. Such studies will guide appropriate policy formulation in drought management.

CHAPTER 4

IMPACTS ON NATURAL RESOURCES, WATER, FOREST AND LAND

4.0 Introduction

Water is an important resource to sustain life and lack of it undermines efforts to improve the quality of life among people. As an important resource in all sectors of society, be they domestic, industrial or agricultural, a fall in its supply will usually have far reaching effects. In Kenya, agriculture accounts for the highest water consumption (76%) followed by domestic use (20%), and industrial use only 4% (UNEP 2000).

The main source of recharge for both surface and ground water is precipitation in the catchment areas during the long (March-May) and short (October-December) rains. This cycle should be consistently maintained for continued balance between the usage and replenishment.

The *El Niño* phenomenon of 1998 for example, brought about heavy rains resulting in improved reservoir recharge. However the persistent drought of 1999-2000 wiped these gains and underscored the fact that water is still a limited resource that requires sustainable management. Widespread deforestation of key water catchment areas is already affecting the nation's water resources. Deforestation has severely affected the indigenous forest blocks, constituting three quarters of the total indigenous forests in Kenya namely the Mau, Mount Kenya, Mount Elgon, Aberdares and Cherengani (Table 4.1). Their aggregated catchment protection value in 1994 was estimated at over 1.9 billion Kenya shillings (KFMP 1994), which forms 91 percent of the total water catchment protection value of forests in Kenya. Deforestation has reduced the capacity of these water catchments to regulate run-off with subsequent flooding as experienced in the Kano plains.

It has been reported that Kenya's forest cover stands at 1.7%, way below the accepted world minimum of 10% with an estimated reduction rate at 3% per annum (based on Table 4.1 below depicts the loss in forest cover between 2000 and 2003). The crucial economic role of forests as water catchments was underscored in the year 2000 when reduced water levels in power generating dams led to power rationing that adversely affected production of consumer goods causing soaring inflation in the country. However, in spite of all this, indigenous forests continue to remain targets of excisions and clearance.

Table 4.1 Forest cover changes between 2000 and 2003

Forest	Affected Area	Total Area	Percentage	Water catchment
Mau	5318.4	271360.8	1.96	Mara
Mount Kenya (including park)	6013.5	271399.5	2.22	Tana/Athi
Mount Elgon (including park)	1874.4	102695.6	1.83	Ewaso Nyiro
Cherengani	174.3	97397.4	0.18	Ewaso Nyiro
Aberdare	Cloudy	243217.7	-	Athi

Source: The UNEP/ Kenya Wildlife Service aerial survey report of the Aberdares, April 2003

4.1 Forest Statistics Change in Forest Cover between 2000 and 2003

Apart from Aberdares forest, forest cover generally declined by between 2.2 percent for Mount Kenya to 0.18 percent for Cherengani.

The UNEP/ Kenya Wildlife Service aerial survey report of the Aberdares of April 2003 showed destruction of the forest through various ways as shown in table 4.2 Among the human factors contributing to this level of destruction are poverty, unsustainable livelihoods and the high population growth rate. The 1999-2000 droughts have also significantly affected the health of plants, contributing to the reduced water volumes and to environmental degradation in general. Such droughts have further resulted in increased exploitation of forest resources as people turn to alternative sources of income in such periods by transforming wood into charcoal or selling it as timber.

Table 4.2. Forest disturbances on Aberdares forest reserve

Type of destruction	Unit	Quantity
Livestock grazing	Heads	18497
Burnt forest areas	Forest areas	21
Illegal cultivation	Fields	170
Charcoal burning	Kiln	14,499
Logging	Tree	9,425

Source: The UNEP/ Kenya Wildlife Service aerial survey report, Aberdares, April 2003

4.2 Impacts on surface water

The volume of water in rivers and other reservoirs has continuously decreased over the years due to changes in landuse (figure 4.1a). Lakes continue to be degraded (NEMA, 2003) by a combination of siltation, reduced inflow and encroachment by invasive plant species. Collection pans, wetlands and streams are targets of encroachment by agricultural activities. These practices could have contributed significantly to the drying up of some of these water sources in arid and semi-arid lands leading to severe shortage and low recharge of underground reserves. For example the reduced water volumes of the Lorian (UNEP/GOK 2000) have directly affected the water levels in boreholes in Biyamadhal area of North Eastern province. In general, the national water deficit was estimated at 704, 522m^3, with some rivers completely drying up. Figures 4.2, 4.3, 4.4, 4.5 show the conditions of some of these water sources during the drought.

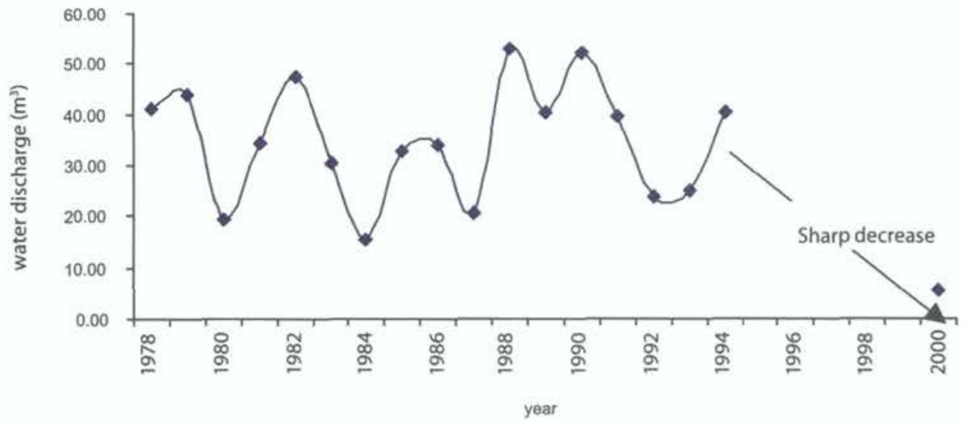


Figure 4.1a. Water discharge from mid Tana River basin (1978 - 2000) in M^3. *Source: KenGen*

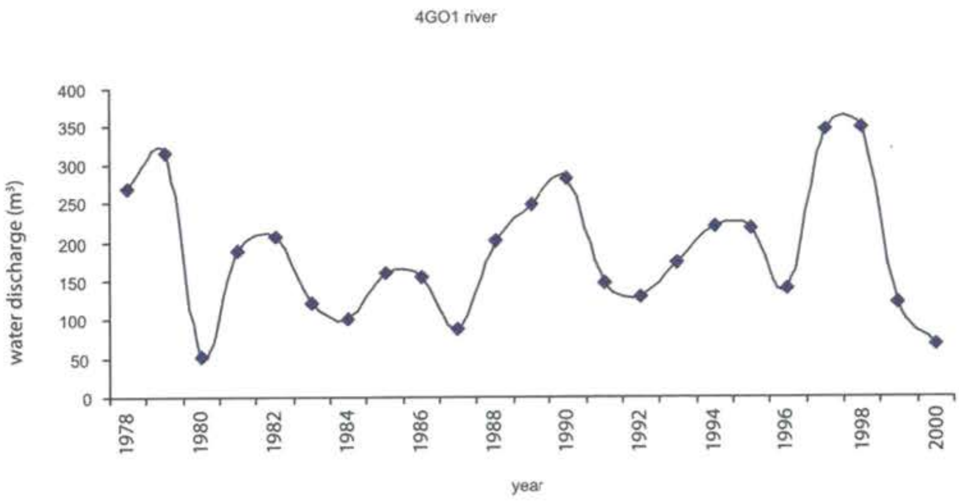


Figure 4.1b Water discharge from the Upper Tana River basin (1978 - 2000) in M^3, *Source: KenGen*

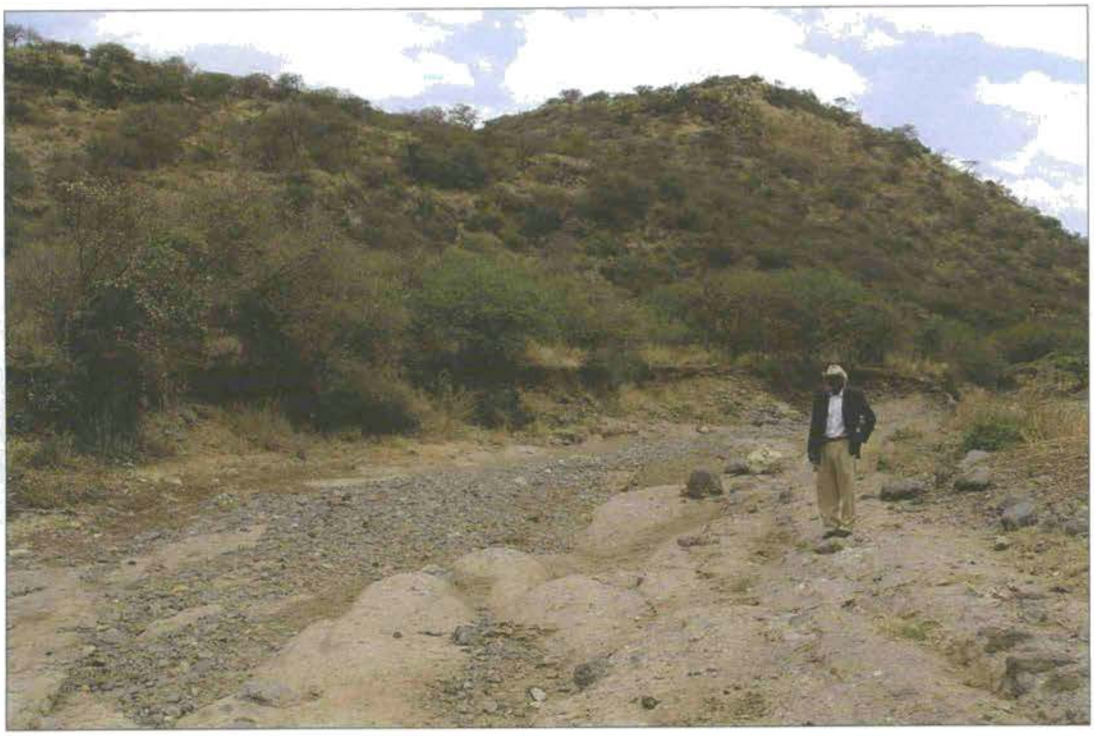


Figure 4.2 A dry riverbed in a semi-arid area (Kajiado)
Photo by A. Odour (RELMA in ICRAF)

Figure 4.3 Dry water pans in a semi-arid area in Machakos district
Photo by A. Odour (RELMA in ICRAF)

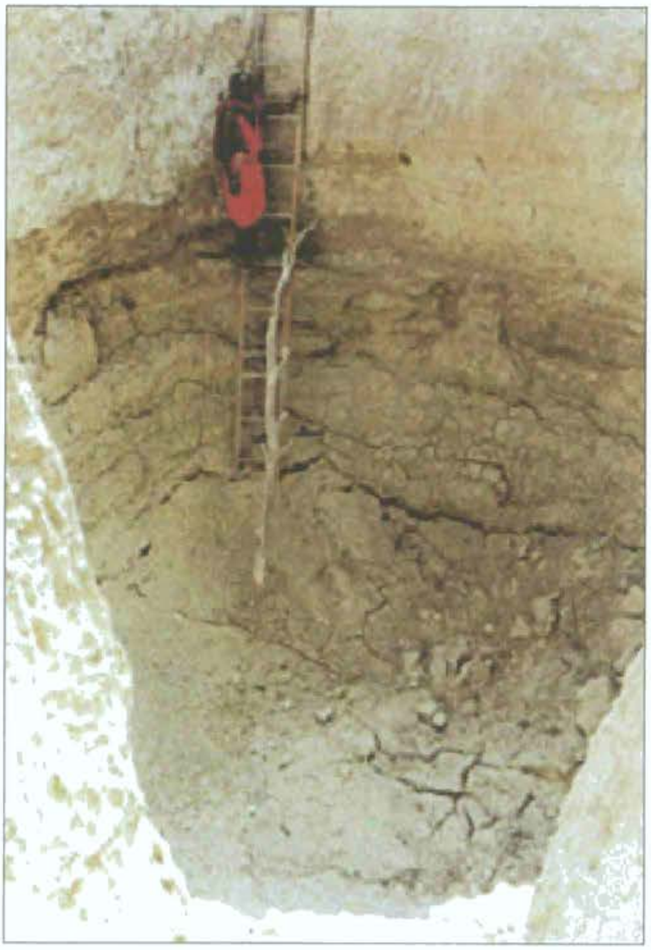


Figure 4.4. A dried well due to persistent drought (Courtesy of AWI quarterly)

Figure 4.5 Productive wetland

The volume of water in urban water supply dams decreased drastically (as high as 70% for Sasumua dam) in tandem with the decreased river flows at the height of the drought. Nairobi's installed water supply, which was 519,000 m^3 per day, then only received 274,900 m^3 per day, way below the normal demand of 346,600 m^3 per day (Makuro, 2000). This resulted in water rationing and mushrooming of water vendors whose water was at times of questionable quality. The daily loss in revenue was estimated at US $50,000 for Nairobi at the height of the drought.

4.3 Impacts on groundwater

The increased demand for water has triggered increased abstraction of underground aquifers through the sinking of boreholes particularly in the urban centers within the city of Nairobi (figure 4.6). Sinking of some of these boreholes, especially during the height of water crisis disregarded the criteria of 800m-separation distance. This could have long lasting effects on the aquifers and structures through weakening of foundations, which could be detrimental in the long run. For example, Mexico City sunk by more than 10 meters in the last 70 years from overexploitation of the ground water (UNCHS-Habitat, 2000).

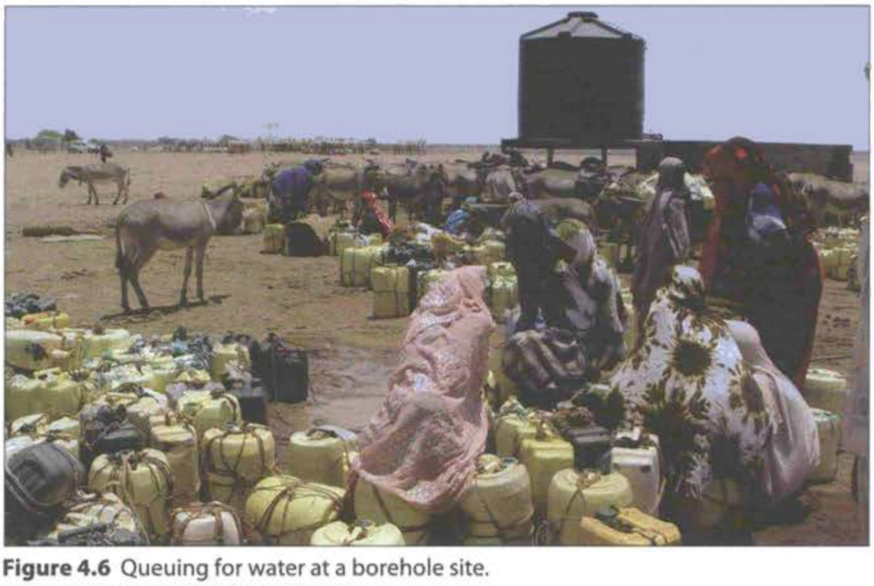


Figure 4.6 Queuing for water at a borehole site.
Photo by A. Odour (RELMA in ICRAF)

4.4 Economic impacts

The seven folks dams are all located along the Tana River. They have had relatively average high levels over the years of around 1055m (for Masinga) even during the 1984 drought (figure 4.7). However, there was a sharp drop in water levels during the 1999-2000 drought, which significantly affected the generation of the country's electric power. This had an impact on the economic activities in the country, considering hydropower contributes 70% of the country's energy generated. Masinga, the main dam in the series reduced power generation by as much as 98% (UNEP/GOK 2000). Even the foundations of the embankments were exposed by the dropping water levels, probably signifying the severity of the situation (personal communication). This critically hampered capacity to generate electricity where Gitaru and Masinga had to close down while Turkwell generated negligible electricity. The fact that this particular station continued to produce electricity is probably reflected on its levels (figure 4.8) that showed a more subtle deviation from the normal relative to Masinga.

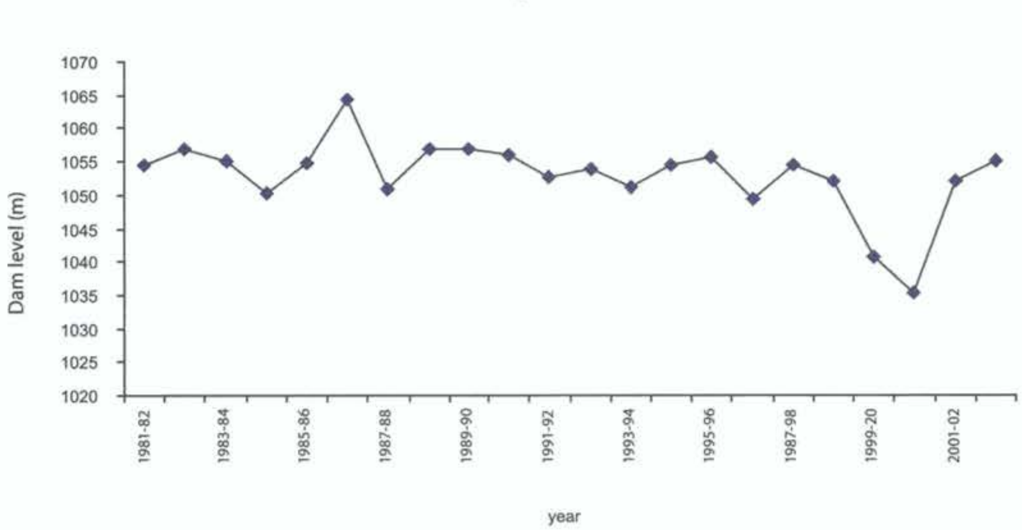


Figure 4.7 Masinga Dam levels over a period of 20 years. *Source Kengen*

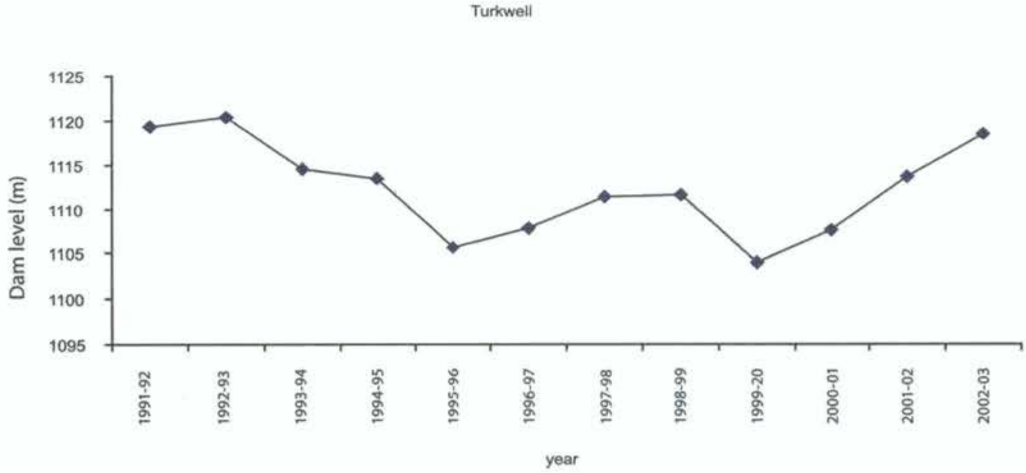


Figure 4.8 Turkwell Dam levels over a period of 10 years. *Source Kengen*

Reduced generation capacity, as previously implied had far reaching consequences on the country's economy and in the worst-cases led to some companies closing down. This increased unemployment levels and contributed directly to increased poverty levels. The reduced generation also led to increased production costs for manufacturing companies, which had to turn to generators as their source of power. This had an effect on commodity prizes with noise pollution being a side effect of such generation. The government also contracted some companies to provide emergency power supplies powered by petroleum to ease the problem, accruing great cost expenses. Since few Informal sector businesses operated at reduced capacities, in most cases 2 to 3 hours in a day after reconnection. They could afford the luxury of generators, (e.g. welding and hair salons outlets). Advertisers were also reported to pull out their slots from television stations since there were no guarantees their commercials would be watched (Warah, 2000), which meant loss of revenue on the part of the broadcasting stations. Government loss of revenue was estimated at $2 million per day, a big blow to an already struggling economy (UNEP/GOK 2000).

4.5 Social impacts

The drought and, in particular, scarcity of water, disrupted the social setup of people. In extreme cases, there was migration to other areas, disrupting schooling for some children as some classes had to be rescheduled. Some people moved their families from urban to the rural areas. An example is (Daniel Oyuga Anyimu from Kangemi (Warah, 2000) as water scarcity worsened.
The private vendors took advantage of the desperate situation to raise the cost of the water by 400%. A 2000 litre tanker was reported to cost as high as KSh. 40,000 in Nairobi during the drought. This had wider reaching implications on the buyers since they had to forego some of their basic needs to offset the water budget. It also meant walking long distances to fetch water.

The toll on human health can be inferred from reported decreases in weights e.g. of children in the Kerio Valley Catholic Mission Clinic (Long, 2000) that collaborated well with a survey based on weight for height method (UNICEF, 2000) and decreased hygiene standards.

Effects in the rural areas, where people rely mainly on streams and dams, were also severe and far reaching in terms of demographics, water quality and distances traveled in search of water. There was also an economic implication among the rural population where in extreme cases people had to buy water at exorbitant prices. This had implications on the effort to reduce poverty levels since most people in these areas are unemployed. Increased cost on the water therefore affected their purchasing power negating the government efforts to reduce poverty. Table 4.3 shows the effect among the rural population in the pilot district of Kajiado where a group of thirty people were interviewed. In general, people walked longer distances in search of water during the drought compared to the preceding period. The table also shows the most affected of the water sources were dams whereas the least affected were boreholes.

Due to the desperate nature of the problem, the quality of water was not a priority. People collected water from the nearest source available even in livestock watering points (Figure 4.9), increasing the occurrence of water borne diseases such as cholera.

Competition for water at the few sources also led to conflicts. In Kieni, Nyeri farmers competed for water to irrigate their crops, disadvantaging the farmers downstream and leading to confrontations. The prolonged drought also intensified the conflict between the Pokot and Marakwet in the Kerio valley. The Pokot fed their livestock on the Marakwet irrigated crops (Long, 2000).

In Naivasha, there were also conflicts between the farmers and the Masai pastoralist. The movement of large herds into the urban centers due to inadequate pasture lead to congestion on roads and quarrels with city residents in affected estates. Nairobi city residents in various estates such as Embakasi learnt to live with the livestock (Figure 4.10). It was estimated that as high as 75% of Kajiado district herds were driven into towns (Integrated Regional Information Networks (IRIN), 2000).

Table 4.3 Water sources distribution before and after the drought for a small community in Kajiado

Source	Rivers /springs Before	Rivers /springs During/after	Wells Before	Wells During /after	B/holes Before	B/holes During /after	Dams Before	Dams During /after
No.	14	9	22	13	34	26	58	5
Average distance	1km	1-2km	0.5-1km	1-3km	3km	3km	0.5km	>2km

Figure 4.9 Watering livestock in a dam used to draw water for domestic use

Figure 4.10 Livestock grazing in residential areas within Nairobi due to lack of pasture in the arid areas

4.6 Discussion and Recommendations

The drought had adverse effects on almost all sectors, indicating the central role that water plays in life and thus the need to utilize it sustainably. It is apparent that the drought even affected the water table in river catchments. The slow and general decrease in river flows, and increased soil erosion over the years and, could have compounded water crisis.

Poor catchment management also contributed to water shortage. Over the years, poverty has pushed the population to cultivate unsuitable lands, for example farming on steep slopes, thus reducing water infiltration into the soil during the wet season, increasing flash floods and soil erosion resulting in the siltation of both the rivers and reservoirs (Figure 4.11).

The economic effects reflect the inter-relationship between the various sectors and thus their dependence on adequate water supplies. It is also a warning to the country to reduce its reliance on hydropower and diversify to wind, geothermal and other electric power sources. With five of the hydroelectric dams on a single river (Tana), the situation is further limiting and probably calls for diversification of hydroelectric generation to different rivers.

Results of the drought also reflect the poor level of preparedness among the various stakeholders, probably due to lack of access to early warning information. The country has the necessary institutional infrastructure to mitigate disasters, but lacks coordination and adequate capacity to manage the disasters (Mutua, *et al*, 2004). There is need for the reorganization and strengthening of these institutions and enabling communities to monitor the onset of such disasters.

Inadequate water storage capacity in the form of pans, dams, underground storage dams and even industrial tanks could also have added to the general water shortage. If rainwater had been harvesed during the *El Niño* event, it would have alleviated the impacts of the drought. In the urban areas such as Nairobi, the situation was aggravated by a poorly maintained water system, as 50% of city's water is unaccounted for. There is a clear and urgent need to improve the management of existing water.

Kenya is a water scarce country and concerted efforts are needed to preserve the little that is currently available. The establishment of the National Water Conservation and Pipeline Corporation (NWCPC) in 1988 to improve water supplies seems to have had little impact. The government needs to increase its efforts to educate its people on the need to conserve water. The newly established National Water Policy (2002) is definitely a step in the right direction, setting out objectives for involving all stakeholders in water resources management.

Rainwater harvesting strategies need to be developed for the domestic, agricultural and industrial sectors, as has been done successfully in India. In so doing, the use of low cost technologies will be encouraged. Increasing damming of rivers where other environmental

Figure 4.11 Poor land management in catchment areas leading to soil erosion

Photo by A. Odour (RELMA in ICRAF)

impacts are taken into consideration is also recommended. This will provide water not only for domestic purposes, but also for productive uses such as irrigation and electricity generation, thus contributing to poverty alleviation.

Both the private and public sectors should be encouraged to invest in the water sector to avoid the current pitfalls where little attention is paid to consumer satisfaction, operation, maintenance and cost recovery. The 2002 Water Act provides a framework for this.

The importance of the watershed and implications associated with degradation in terms of loss of soil cover, reduced agricultural production, altered hydrology, and water quality should be made clear during awareness creation programs. Such an approach will maximize the economic and social welfare benefits without compromising sustainability of the resource.

Establishment of a reliable database is recommended to provide a source of real time monitoring of water balances in times of drought. The data should also be regularly updated to enable recognition of anomalies well in advance, taking into consideration that the drought is usually the result of a variety of factors over a long period of time.

Community participation should also be used to manage catchment and rehabilitate the degraded areas. This should include sensitization on proper land use practices and conservation of forests. The critical role of forests in recharging water sources should be shown clearly. It is also necessary to raise the awareness of the stakeholders on the need for afforestation in catchments. Women who are the most affected in the case of shortage should be fully involved in water management schemes. Their involvement will lead to sustainability since improving access for them will lighten their burden and allow for their development in other areas.

Public awareness campaigns on the need to use water efficiently should be carried out through the newly established Water Management Authority. This will not only help in revenue savings but also guarantee supply in the time of scarcity.

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The Director,
Department of Resource Surveys and
Remote Sensing
P.O. Box 47146, 00100, Nairobi
Tel: 254 (020) 7609013/27
Fax: 254 (020) 7609705
E-mail: info@drsrs.go.ke
Website: www.drsrs.go.ke

www.unep.org
United Nations Environment Programme
P.O. Box 30552 Nairobi, Kenya
Tel: (254 20) 7621234
Fax: (254 20) 7623927
E-mail: uneppub@unep.org
web: www.unep.org

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