APPENDIX B

Terrestrial Ecology Study for a Proposed 100MW Wind Energy Project, Kajiado District, Kenya

Report Prepared for

Kipeto Energy Limited

March 2012

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1 Executive Summary

Different aspects of biodiversity play significant role in ecological processes that sustain life and contribute immensely to economic development. Conservation of biodiversity from overexploitation and unnecessary destruction has been considered as an approach to strike a balance between the natural resource management and exploitation by human being. Some human activities do not necessarily exploit natural resources but destroy them in order to get space for development. Ecological Impact Assessment (EcIA) has become handy in striking a balance between the need for this developments and conservation of biodiversity. By employing EcIA, negative impacts of the projects are reduced or avoided through mitigation measures. Where neither of the two happens then compensation is followed to provide an alternative for biodiversity.

Kipeto Energy Limited intends to construct wind turbines in Kipeto area for harnessing wind energy. The project will construct over 200 turbines, a substation and install underground cables. Also, access road in the area will be constructed for transportation of equipments to sites of construction. The project is envisaged to affect the current status of environment. It is important to understand how associated activities would affect habitats and species that exist in Kipeto area. To pursue this, the scope of study was established and field survey carried out. Field survey was carried out in two phases; during wet and dry seasons. Sampling and physical observations were done along transects and on plots. Taxa that were surveyed included mammals, herpetofauna, insect pollinators, and plants. Species diversity and distribution was analyzed for Kipeto area. The list of species was run on IUCN list of threatened species to check on the global conservation status of the species. In addition to this, conservation considerations of local species were inquired from various authorities in Kenya.

Kipeto area is characterized by unique vegetation covers comprising of open grassland dominated by *Themeda, Digitaria, Chloris, Pennisetum* and *Sporobolus* species. It has bush and woodland dominated by *Combretum*, *Grewia*, *Acacia*, *Rhus* ,*Premna* species, *Acacia tortilis –Commiphora*. Most of woodland and bushland tend to be near or in the valleys in the area. These areas plays an important role in the distribution of wild-herbivores. Two main mammals, Zebra and Thompson Gazelles were conspicuous in the area. Insect pollinators, especially bees and butterflies were recorded mostly near or in the valleys with vegetations. There were marked differences in observations made on the distribution of mammals and insect pollinator species in dry and wet season, and grassland and bush/woodland in Kipeto area. Generally most of the species of mammals were observed in bushland/woodlands near riverine. During dry season the number of species and population observed were few compared to wet season. One species of plant *Osyris lanceolata* (Sandalwood tree) is of particular concern to national conservation due to its value to fragrance industries and trade.

Potential risks and impacts were identified during scoping and analysis of field data. Main components of the project such as construction of wind turbines, internal and external substations, installation of underground cables and construction of roads to sites and internal access roads. Project components and activities analyzed of their potential impacts on terrestrial vegetations, sensitive habitats, priority plant species, insect pollinators, mammals and herpetofauna. Significant impacts of the project are clearing of vegetations and excavation during construction of wind turbines, substation and access roads. These impacts potentially affect species ecology, habitat connectivity. Mitigation measures were suggested towards protecting them. This involves avoiding construction on areas that have sensitive habitats and isolations of priority plant species.

Through analysis of biodiversity aspects and project component, derivation of mitigations was made. With a careful implementation of the mitigation measures, the project will not pose environmental challenges in the area.

2 INTRODUCTION

2.1 Terms of Reference

2.1.1 Rationale for Insect Pollinators survey

Insect pollinators (bees and butterflies) are bio-indicators as individuals and populations in that they can be used to monitor environmental stress brought about by diseases, parasites, predators, chemical and physical factors particularly pesticides and habitat modification (Kevan, 1999). Natural pollination of the insects is appreciated in ecological and agricultural production, improving quality and quantity. For instance, forests or wild grasslands with pollinators near agricultural crops such as coffee, and fruits trees can improve yield by about 20 % (http://en.wikipedia.org/wiki/Pollination).

2.1.2 Rationale for mammals survey

Most of mammals are indicator species that define particular characteristics of environment. They are usually affected by spatial developments that destroy their ecology including habitat ranges. Large and small mammals are affected varyingly. Large mammals can range over long distances avoiding disturbances. Unlike small mammals for instance rodents that can be affected very fast by habitat fragmentation. In this respect, existing mammals would be used to assess impact of the project on their population distribution and ecology.

2.1.3 Rationale for floral diversity survey

Vegetation is an important part of biodiversity due to their primary role as food and habitat to animal species and in ecological processes. Some plant species are used for socio-economic and cultural consumption. Vegetation can be affected adversely by destructive activities on landscape and are easily fragmented. They normally provide ecological connectivity to animal species in a wider landscape.

3 METHODOLOGY

3.1 Field Survey

3.1.1 Floral Survey

Stratified random sampling was used during the survey. The area was stratified into woodland/grassland and riverine areas. The riverine areas are completely unique in their tree assemblage and cover. This makes it different from the wider plains in Kipeto area. In order to facilitate acquisition of information, random quadrats of 50 x 50 m were used in the woodland-grassland areas. In riverine area, a quadrat of 50 x 50 m was used on both side of the river/stream (seasonal). A plotless method was also used to improve on the list of species in the area.

Attributes that were assessed comprised of species composition. Species distribution in the wider area of the project was assessed by using a check matrix for species in every site of survey. The tree-shrub species were mainly focused on during the survey. Species identification was conducted in the field and specimen vouchers and images taken for improved identification.

3.1.2 Ethno botanical surveys

Besides generating quantitative data on floral diversity and distribution, uses of floral diversity resources among the locals were inquired through focused discussions with key individuals. This substantiated the role of the diversity among the Maasai community.

3.1.3 Faunal Survey

Mammal survey: Physical observation was undertaken in the area for mammal diversity. This involved walking across the area through established transects. Road side observations were used to yield information on the diversity. Camera traps were positioned in bush areas to record common mammals in the areas.

Insect Pollinator Survey: The survey sites had various habitat types that provided options for sampling by habitat characteristics. Habitat characteristic included grassland, shrub and bushland, riparian woodland. Sweep nets were used to catch butterflies and bees in flights. Light traps were used to assess moth existing in the areas. Physical observation was also conducted for species that were not caught by the traps.

Herpetofauna survey: Observation was done with special search in the area. The search was concentrated on tree stems, shrubs and herbs. Stony areas were targeted in the morning when the sun just hit the ground to observe buskings. Also stones were rolled over to look for individuals hiding. Observation was also done on road crossings.

Verbal accounts from local people: Various discussions were held with the local communities on the species diversity and their local value to the community for various taxa. Focused group discussion was employed in order to acquire further information from the local people.

3.2 Sensitivity mapping

Sensitive areas to project construction will be visualized on maps. These areas include local migration routes for mammals, riverine vegetation (habitats) and areas with endangered plant species.

3.3 Assessment of Impacts

It is envisaged that the project would have various impacts on the biodiversity of Kipeto and a wider ecosystem. These include impact on terrestrial vegetation, sensitive habitats, priority plant species, insect pollinators, mammals and herpetofauna.

The nature of these impacts depends on the kind of activities at the construction phase and operational phase of the project. The assessment of impacts has involved description of the nature of the impact, which comprises description of what causes the effect, what will be affected and how it will be affected. These impacts can be evaluated in spatial content. Depending on its extent, the impact can be limited to the project site and to specific activity at particular period, or affect areas beyond the project site. Duration in which the impact takes place is also considered in the evaluation of the impact. The period can be specific to the period of certain activities or could be related to the occupancy period of the project development. Thus, in terms of duration an impact can be viewed as a short, medium, long term impact or permanent. Impact can affect biodiversity partially or completely. For instance only small part of habitat, ecological processes or small population of species can be destroyed by the impact. Thus, magnitude of an impact was evaluated as proportion of the environmental entity affected. The likelihood (probability) of the impact to happen depends on the frequency of the activity and frequency of impacts. Characteristics described above were used to synthesise significance of the impact.

Definitions

Activity:	Distinct process or task undertaken by an organization for which a responsibility can be assigned
Frequency of activity:	Refers to how often the proposed activity will take place
Frequency of impact:	Refers to the frequency with which a stressor (aspect) will impact on the receptor
Magnitude of impact:	Refers to the degree of change to the receptor status in terms of reversibility of the impact (proportion of the environmental entity affected)
Geographic extent of impact:	Refers to the geographical scale of the impact
Impact duration:	Refers to the length of time over which the stressor will cause a change in the resource or receptor

3.3.1 Significance of the impact

An environmental risk assessment criterion was used to analyze significance of impacts on ecological parameters. This criterion took into account the likelihood of the impact to occur based on frequency of activities and frequency of impact, and; consequences of impact based on the magnitude, spatial extent and duration of the impact.

Table 1: Criteria for assessing significance of impacts

CONSEQUENCE

Magnitude of Impact	Rating
Negligible	1
Minor	2
Marginal	3
Significant	4
Catastrophic	5

Geographic Extent of impact	Rating
Activity specific	1
Project specific	2
Local area	3
Regional	4
National	5

Impact duration	Rating
<1 month	1
1 - 12 months	2
13 - 36 months	3
37 - 72 months	4
>72 months	5

LIKELIHOOD

Frequency of activity	Rating
Annually or less	1
6 monthly/temporary	2
Monthly/infrequent	3
Weekly/life of the operation	4
Daily/permanent	5

Frequency of impact	Rating
Almost impossible	1
Highly unlikely	2
Unlikely	3
Possible	4
Definite	5

Significance of the impact is a factor of consequence of impact and likelihood of impact, whereas consequence of the impact is calculated as the sum of magnitude, geographic extent and duration of impact, while Likelihood of the impact is the sum of frequency of activity and frequency of impact.

Table 2: Significance ranking matrix

SIGNIFICANCE

LIKELIHOOD (Frequency of activity + Frequency of impact)	CONSEQUENCE (Magnitude+Geographic Extent+Duration of impact)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	
3	6	9	12	15	18	21	24	27	30	33	36	39	42	45	
4	8	12	16	20	24	28	32	36	40	44	48	52	56	60	
5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	
6	12	18	24	30	36	42	48	54	60	66	72	78	84	90	
7	14	21	28	35	42	49	56	63	70	77	84	91	98	105	
8	16	24	32	40	48	56	64	72	80	88	96	104	112	120	
9	18	27	36	45	54	63	72	81	90	99	108	117	126	135	
10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	

POSITIVE/NEGATIVE MITIGATION RATINGS

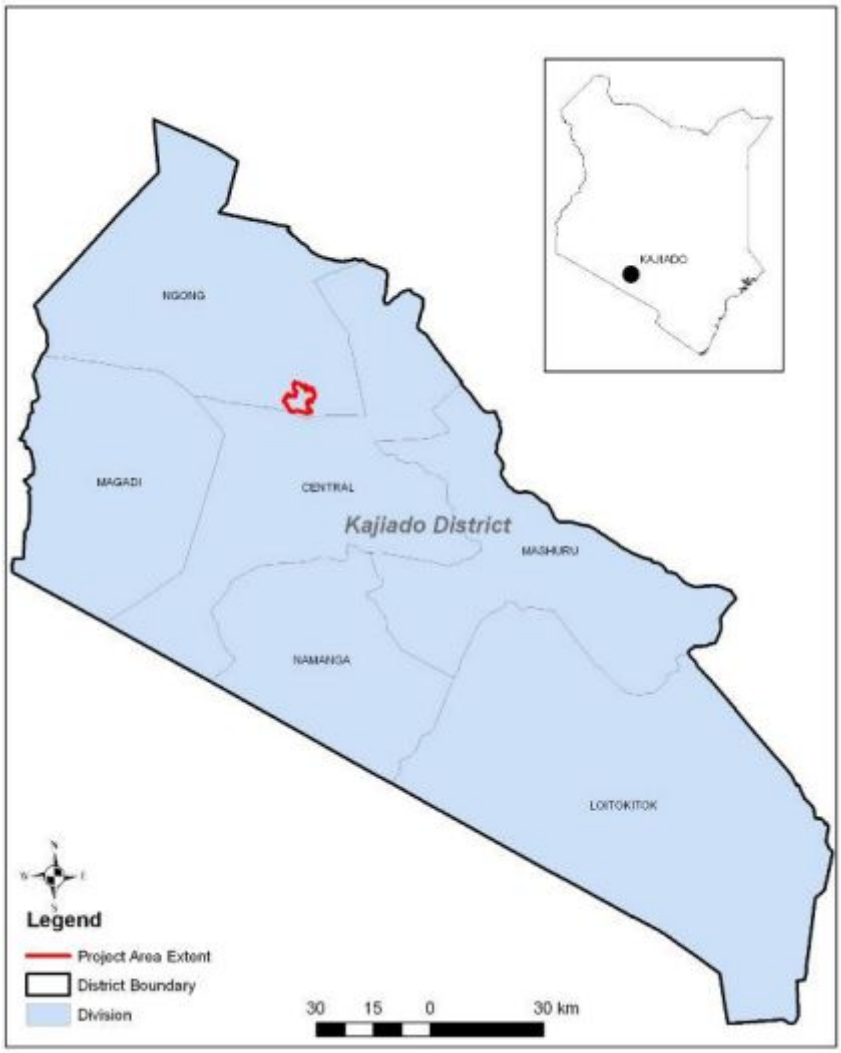
Significance Rating	Value	Negative impact management recommendation	Positive impact management recommendation
Very High	126-150	Propose mitigation measures	Maintain current management
High	101-125	Propose mitigation measures	Maintain current management
Medium - High	76-100	Propose mitigation measures	Maintain current management
Low - Medium	51-75	Maintain current management	Propose mitigation measures
Low	26-50	Maintain current management	Propose mitigation measures
Very Low	1-25	Maintain current management	Propose mitigation measures

4 BASELINE INFORMATION-DESCRIPTION OF STUDY AREA

4.1 Location of Site

The proposed project site is located in Kipeto area, which lies in Kajiado District. The district is located south of the Rift Valley province where it borders the Republic of Tanzania to the south-west, Taita-Taveta District to the south-east, Machakos and Makueni District to the east, Nairobi to the south-east, Kiambu District to the north and Narok District to the west. Spatially, Kajiado District lies between longitudes 36^0 5' and 37^0 5' east and between latitude 1^0 0' and 3^0 0' south. Kipeto area is situated in south-east of Ngong Division lying between latitude 1^0 45' S and longitude 36^0 42'.

Figure 1: Map showing location of the project. Inset is a map of Kenya

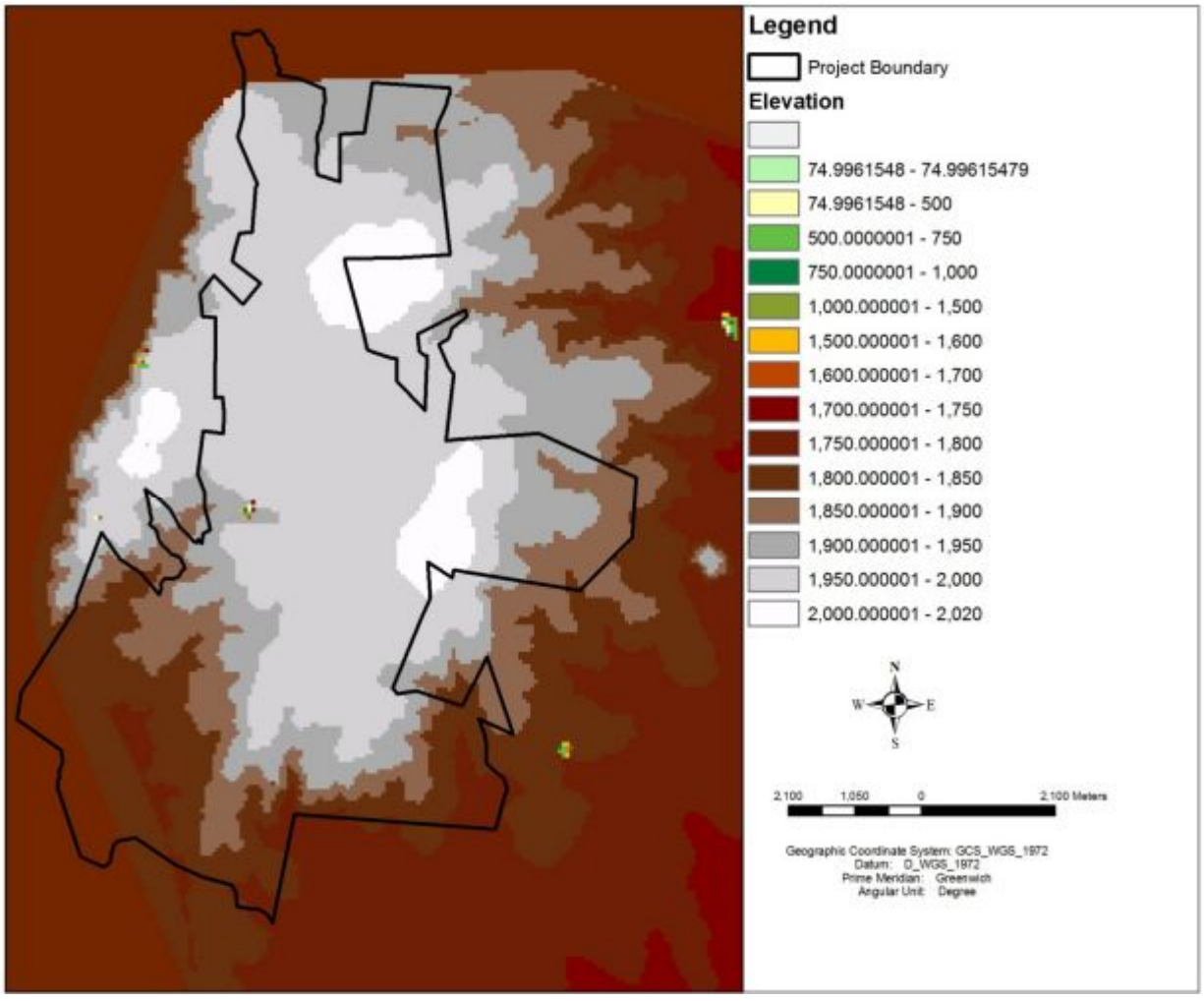


4.2 Topography

The topography of Kajiado District is characterized by plains and few volcanic hills. The plains are dissected by several valleys. The land rises from 500 meters above sea level (asl) around Lake Magadi to about 2500 m asl in the Ngong Hills area. Generally the landscape falls between altitude 1760 and 2023 m asl generally, topography of Kajiado District can be divided into four different eco-zones; The Rift Valley, Athi Kapiti Plains, Central Broken Ground and the Amboseli Plains. The proposed wind energy facility occurs in the Athi Kapiti Plains, which consists of open rolling land. The area includes the Ngong Hills with an altitude of 2460m asl. Two major tributaries emerge from Ngong Hills which include Mbagathi and Kiserian both of which are permanent.

Most of Kipeto area lies between altitude 1950 – 2000m asl. Landscape on the western side of the area falls rapidly to give rise to the escarpment of the eastern flank of the Rift Valley (Figure 2). There are valleys, which form seasonal streams that radiate to the north east and south east from the undulating higher altitude landscapes.

Figure 2: Map showing elevation zones in Kipeto area



4.3 Drainage and Water Resources

Kajiado County does not have permanent natural sources of surface water. The main surface water systems include the Uaso Nyiro River in the Rift Valley, two streams in the northern part of the Athi-Kapiti Plains, the Kiboko River, which drains much of the Central Hills and the northern part of the Amboseli eco-zone, and several springs in the southern part of the Amboseli zone. Generally, Kajiado County experiences shortage of water due to lack of surface waters mostly rivers and streams due to their seasonality. There is low precipitation in most parts of the county and frequent droughts are experienced in most parts. Most of areas around Ngong form catchments of the Upper Athi River. Kipeto drainages are seasonal that feed into the Kitengela River during rainy season.

Kipeto area occurs in lifted Plain landscape with drainages emerging from the area in radial pattern. These drainages or rivers/streams are seasonal but during rainy seasons they deliver large volume of water from Kipeto landscape (catchment). An escarpment that occurs to the western part of Kipeto marks the eastern highlands of the Rift Valley where the Aberdare Forest, Nairobi area, Kiserian/Ngong areas occur. This escarpment drops suddenly and forms drainage features that direct runoffs to the floor of the Rift Valley serving inland water system such as the Lake Magadi to the west and Lake Natron to the south west.

A survey of the water resources revealed existence of substantial water resources in Kipeto area that serve during dry seasons in the area. The seasonal river has dry beds during dry seasons but has "wells" on the beds that contain water during dry seasons (see Fig. 3 – 6). Some of these can serve local community water requirements, livestock and wildlife drinking waters throughout the year. However, most of the valleys are very rugged to be accessed by people and livestock.

There are few existing developed water resources in the area mainly constructed by the Ministry of Water and local initiatives. One dam occurs almost at the centre of the project area at Esilanke Trading Center along a seasonal river that drains to the valley towards the south-west discharging into Lake Magadi. According to the local community, the dam can serve throughout the year. However, livestock normally congest it during dry seasons but near it, there is a water basin that receives water pumped from borehole constructed by the Ministry of Water.

There are more reliable sources of water located far away from most people in the area. Through individual initiatives small water-pans are constructed however, their lifespan is uncertain in dry seasons. An estimated 5 small water-pans were recorded within the open grassland areas in Kipeto that potentially serves livestock and wildlife occurring in the Kipeto plain. There is also indication on the ground that more water-pans would be constructed by individual landowners in the near future since there is demand for water.

Figure 3: Water pump station for the ministry of water

Figure 4: Drinking basin for livestock

Figure 5: Dam constructed a long seasonal stream for watering livestock during dry season

Figure 6: Dry river valley with water pools that serves livestock and wildlife during dry seasons. Insets are photos of water pools used by livestock for drinking and use by the local community.

4.4 Soils

The soils are generally categorised in broad classes in Kajiado. These include the quaternary volcanic soils, basement rock soils and the pleio-cene soils. Most parts of Kajiado district is covered by basement rock soils arising different cycles of erosion. Alluvial soils are found along the river valleys and some parts of the plains. To the western side of Kipeto occurs Lake Magadi, South west is Lake Natron and Lake Amboseli to the south, which has an inland drainage with soils comprising of Pleiocene sediments. Kipeto is located in Ngong Hill area where the soils are composed of sediments from the tertiary volcanic rocks washed down the eastern slopes of the Rift Valley escarpment. Most of the potential project site has black cotton soil; however towards Kajiado town occurs dark reddish brown sandy soil clays. These soils are of medium potential for crop production but support the wider grassland-woodland that provide livestock and wild-herbivores with grazing areas.

Figure 7: Map showing distribution of types of lithology in Kipeto area and environ

4.5 Climate and Agro-Climatic Zone

4.5.1 Rainfall and Temperature

Mean annual rainfall ranges from 300 to 800 mm. Rainfall is bimodal, with short rains occurring from October to December and long rainfall from March to May. Distribution of rainfall between the two seasons changes gradually from east to west across Kajiado District. More rain falls occur during the "short rains" in eastern Kajiado than during the "long rains". In western Kajiado the majority of rain falls during the "long rains". The annual rainfall is influenced by altitude. Temperature of Kajiado District also varies with altitude.

4.5.2 Agro-Climatic Zone

Agro-Climatic zonation is based on the relationship between climate, vegetation and land-use potential. The relationship uses indices such as annual rainfall expressed as a percentage of potential evaporation (E_0). Agroclimatic zone have been used to assess suitability of land for different uses.

In Kenya, agroclimatic zones are divided into seven zones; zones I, II and III have index greater than 50 % and have good potential for cropping. These zones account for 12 % of Kenya's land area. Semi-humid to arid regions consist of zones IV, V, VI and VII, have an indexes of less than 50 % and mean annual rainfall less than 1100 mm.

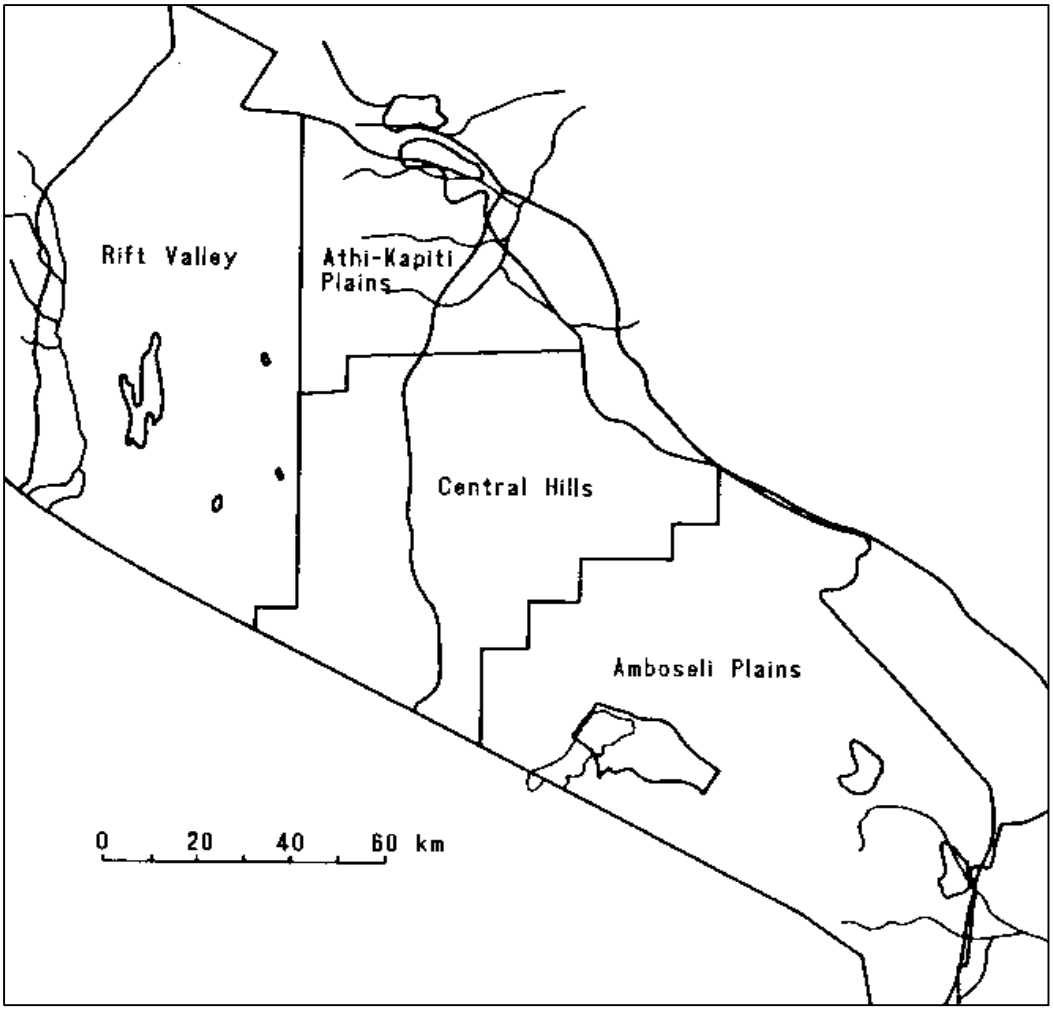
The vast majority of Kajiado District consists of three Agro-climatic zones. These include Semi-humid to semi-arid (ACZ IV), semi-arid (ACZ V) and Arid (ACZ VI) (Table 3). ACZ IV receives an annual rainfall of 600-1100 mm, ACZ V receives about 450-900 mm and ACZ VI receives 300-550 mm. The project area falls in the Athi-Kapiti plains within the agro-climatic zones IV and V, which comprise 31% and 69% of the area respectively (Table 4). Only 8 % of the district land is classified as having some potential for rainfed cropping (zone IV) – most of this is in Athi-Kapiti Plains close to Nairobi, and in the south of the District, along the Kilimanjaro foothills.

Table 3: Moisture availability zones in the Kenya rangelands

ACZ	Classification	Moisture index (%)	Annual rainfall (mm)	Per cent of Kenya's land area (%)
IV	Semi-humid to semi-arid	40-50	600-1100	5
V	Semi-arid	25-50	450-900	15
VI	Arid	15-25	300-550	22
VII	Very arid	<15	150-350	46

Source: Sombroek et al (1982). http://www.fao.org/wairdocs/ILRI/x5552E/x5552e04.htm

Figure 8: Ecozones of Kajiado District (http://www.fao.org/wairdocs/ILRI/x5552E/x5552e04.htm)



	Per cent of ecozone land area in zone:			
	IV	V	VI	Total area(km^2)
Rift Valley	7	71	23	6850
Athi-Kapiti	31	69		2040
Central Hills	14	69	27	4400
Amboseli	15	26	69	6270
Kajiado District	8	56	36	19560

Table 4: Distribution of agroclimatic zones in the four ecozones of Kajiado District

4.5.3 Agro-Ecological Zones

This is a land resource mapping unit, which is defined in terms of climate, landforms and soils, and/or landcover, and having a specific range of potentials and constraints for landuse (FAO, 1996). Generally, AEZ ranges from 0 – 7; the AEZ 0-3 are originally zones of forest according to the natural vegetation. Kajiado District falls in AEZ 4, 5 and 6 with detail AEZ consisting of Lower Highland Zones (LH), Upper Midland Zones (UM), Lower Midland Zones (LM), and Lowland Zones (L). Most of the Athi-Kapiti occurs within AEZ 5 and 6. Within these AEZs there are Lower Highland Zones which potentially support ranching and nomadism, and Upper Midland potentially support livestock keeping, ranching and sorghum cultivation. Lower Midland support ranching, livestock keeping millet cultivation and nomadism (Table. 5). Kipeto area, however, occur in Lower Midland (LM 5 & 6) that merely support livestock keeping, ranching and potential for millet cultivation (Figure9).

Figure 9: Agro-Ecological zones

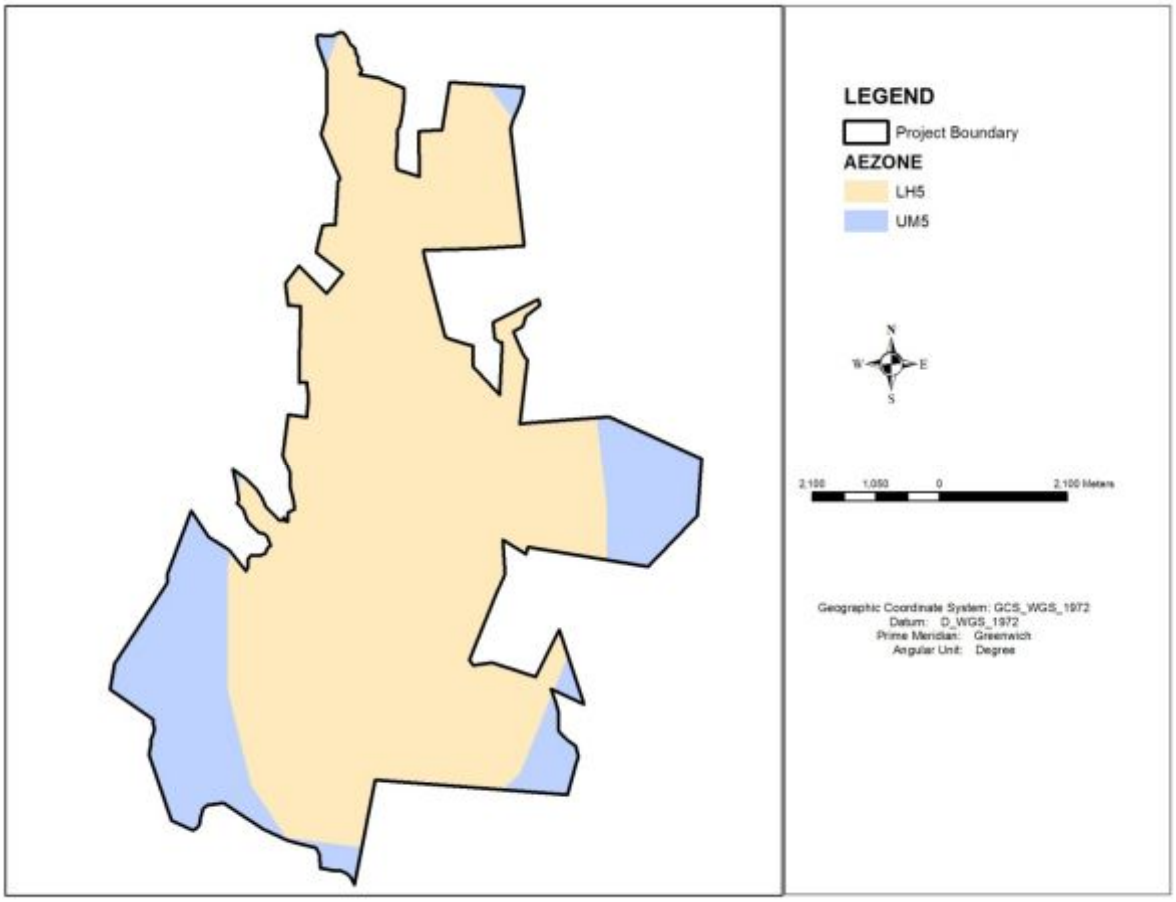


Table 5: Agro-ecological zones of the tropics (source: Kenya Soil Survey)

Main Zones / Belts of Zones	AGRO-ECOLOGICAL ZONES OF THE TROPICS							
	0	1	2	3	4	5	6	7
TA: Tropical Alpine Zones Ann. Mean 2-10^0 C	Mountain swamps	High Altitude Deserts I Cattle – Sheep Zone			II	Sheep		Zone
UH Upper Highland Zones Ann. Mean 10-15^0 C Seasonal night frosts	- ZONE	Sheep-Dairy Zone	Pyrethrum – Wheat Zone	Wheat, barley Zone	U. Highland Ranching Zone	* U H Nomadism Zone		
LH Lower Highland Zones Ann. Mean 15-18^0 C Mean Min 8-11^0 C Norm no frost	FOREST	Tea, Dairy Zone	Wheat, Maize, Pyrethrum Zone	Wheat/IM)[2], Barley, Zone	Cattle sheep Barley Zone	L. Highland Ranching Zone	* L. H. Nomadism Zone[4]	
UM Upper Midland Zones Ann. Mean 18-21^0 C Mean Min 11-14^0 C		Coffee, Tea Zone	Main Coffee Zone	Marginal Coffee Zone	Sunflower, Maize[3] Zone	Livestock, Sorghum Zone	U. Midland Ranching Zone	U. Midland Nom. Zone[4]
LM Lower Midland Zones Ann. Mean 21-24^0 C Mean Min> 14^0 C	*	L. Mid Sugarcane Zone	Marginal Sugarcane Zone	L. Midland Cotton Zone	Marginal Cotton Zone[6]	L. Midland Livestock, Millet Zone	L. Midland Ranching Zone	L. Midland Nom. Zone
L Lowland Zones IL Inner Lowland Zone Ann. Mean > 24^0 C	*	* Rice – Taro Zone	* Lowland Sugarcane Zone	* Lowland Cotton Zone	* Groundnut Zone	Lowland Livestock, Millet Zone	Lowland Ranching Zone	Lowland nom. Zone

Main Zones / Belts of Zones	AGRO-ECOLOGICAL ZONES OF THE TROPICS							
	0	1	2	3	4	5	6	7
Mean Max > 31^0 C								
CL	*	* Cocoa Zone	Lowland Sugarcane Zone	Coconut, Cassava Zone	Cashewnut, Cassava Zone	Lowland Livestock, Millet Zone	Lowland Ranching Zone	Lowland Nom. Zone

1. Inner Tropics, different zonation towards the margins. The T for Tropical is left out in the thermal belts of zonea (except at TA), because it is only necessary if other climates occur in same country. The names of potentially leading crops were used to indicate the zones. Of course these crops can also be grown in some other zone, but they are normally less profitable.
2. Wheat or maize depending on farm scale, topography, a.o.
3. Maize is a good cash crop here, but maize also in LH 1, UM 1-3, LM and L 1-4;
4. Nomadism, semi-nomadism and other forms of shifting grazing
5. An exception because of the vicinity of cols currents are the tropical cold Coastal Lowlands cCL in Peru and Namibia. Ann. Mean there between 18 and 24^0 C
6. In unimodal rainfall areas growing periods may be already too short for cotton. Then the zone could be called Lower Midland Sunflower-Maize Zone

4.6 LANDCOVER AND LANDUSE

4.6.1 Land use Changes

Generally, Kajiado District has experienced land use changes since independence of Kenya in 1963. These changes have been caused by response of human population to both local and external opportunities. Causes of land use changes are many-faceted. According to Africa Wildlife Foundation (AWF) community lands in the Kitengela-Isinya-Kipeto area are used by wildlife of Nairobi National Park for migration and habitation, and by Maasai for livestock grazing. Over period of time, these lands have been privatized, subdivided, and sold. This has resulted in precipitous development; fragmented and fenced-in plots; and degraded land that is increasingly susceptible to drought and other ecological pressures. In order to address these issues a Land Use Master Plan (LUMP) commonly known as the Kitengela, Isinya and Kipeto LUMP was developed and launched recently by the Kajiado Lands Right Forum and have been approved by the Lands Ministry. The LUMP was necessitated by numerous development challenges in the area. This LUMP was driven by community and specifies how land will be used in the area. It provides a sustainable, 20-year framework for wildlife dispersal and livestock grazing across 60,000 hectares of Kitengela-Isinya-Kipeto area, located south of Nairobi National Park. This is envisaged to contribute in balancing community long-term requirements with the survival of wildlife population.

4.6.2 Vegetation and Landcover Types

The common vegetation types predominant in Kajiado District are open grasslands, wooded and bushed grassland, bush and woodland, and forests. Among these types, bushes and woodland occupies larger area of the district ranging 44 % of the total area of the district. This is followed by the open grasslands, and wooded and bushed grasslands, which occupies 26 % each. Forest only covers 2 % of the district. Vegetation cover varies in various areas within the district. About 75 % of Central Hills is occupied by bushes and woodland compared with the Amboseli, Athi-Kapiti Plains and Rift Valley with 59 %, 29 % and 16 % cover, respectively. Open grassland occupies 71 % of the Athi-Kapiti plain, Amboseli plains is covered by 37 % of open grassland, Central Hills 14 % and 9 % of open grassland covers Rift Valley Ecozones. Wooded and bushed grassland cover type is common only in the Rift Valley (74 %) and Central Hill (10 %) (See Table 6 below for more details).

Table 6: Percentage of land area under vegetation of different types in the four ecozones of Kajiado District

Woody cover (%)	Per cent of area					
	Vegetation type	Rift Valley	Athi-Kapiti Plains	Central Hills	Amboseli Plains	Total
0-2	Open grassland	9	71	14	37	26
2-20	Wooded and bushed grassland	74		10		26
20-40	Bush and woodland	16	29	75	59	44
> 40	Forest and other types	1		1	4	2

Source: Based on Croze (1978) and Republic of Kenya (1982).

Grassland is dominated by *Themeda, Digitaria, Chloris, Pennisetum* and *Sporobolus* species. Distribution of the species is related to altitude and edaphic factors for instance; for instance *Themeda* occur at altitude range of 200-1100 m, *Chloris* at 450-1200 m. Common grassland types in Athi-Kapiti is the *Themeda-Acacia drepanolobium*. Digitaria-Chloris types occur in the plains in eastern Kajiado; while Sporobolus type is common on the saline-sodic clays in the Amboseli ecozone.

There are four main types of bush and woodland in Kajiado District. Tarconanthus types occur on shallow soils in the northern Rift Valley. Hill slopes are predominated by semi-deciduous bushland with *Combretum*, *Grewia*, *Acacia*, *Rhus* and *Premna* species. *Acacia tortilis –Commiphora* bush and woodland occur in the Central Hills and western Amboseli where shallow soils overlie basement complex parent material. Open *Acacia tortilis* woodland occurs on lacustrine plains in parts of the Amboseli ecozone.

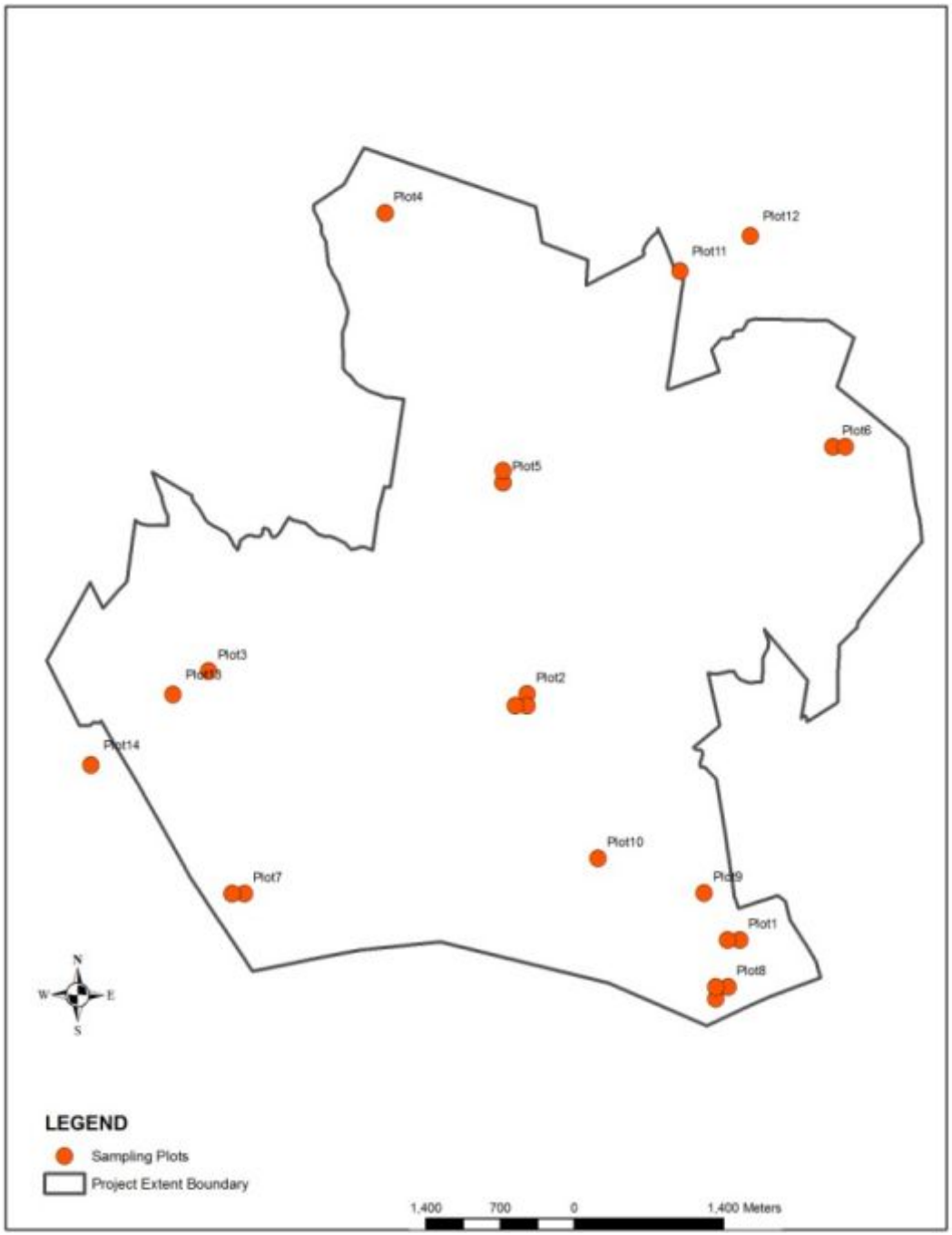
Kipeto area is characterized by open grasslands, wooded grasslands. Some parts have thick bushes comprised of a variety of *Acacia* and *Commiphora* species. Wildlife in the area is freely dispersed in the open plain.

Table 7: Vegetation distribution in the Project area (see map below for distribution of sampling plots)

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	Plot 9	Plot10	Plot11	Plot12	Plot 13	Plot14
Acacia nilotica	151	0	88	45	0	1	0	36	0	2	0	0	23	0
A. abyssinica	0	0	0	0	0	0	0	11	0		0	0	0	0
A. xanthophloea	0	0	0	0	1	0	0	75	31	3	1	0	0	0
A. drepanolobium	0	125	0	0	19	0	41	0	0	0	0	0	0	0
Commiphora sp1	0	0	34	21	0	1		43	0	0	0	0	39	17
Acacia sp.1	0	0	67	70	0	0	0	12	0	0	0	0	47	3
Ovolisifolia sp.	0	0	6	0	0	0	0	53	13	0	0	0	0	0
Vangueria sp.	0	0	23	1	0	0	0	7	0	0	0	0	14	4
Balanites aegyptiaca	0	0	0	0	0	0	0	32	1	0	0	0	0	0
Sand paper tree	0	0	0	0	0	0	0	1	0	2	1	2	3	4
A. tortilis	0	0	0	1	0	0	0	2	12	63	1			0
Croton dichogamous	0	0	34		0	0	0	2	1	0	0	19	133	166
Croton macrostachus	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Grewia similis	0	0	21	10	0	4	0	5	0	0	1	0	43	0
Kaitachme sp.	0	0	5	5	0	11	0	2	1	0	14	1	18	0
Carissa edulis	0	0	11	14	0	6	0	0	2	18	0	0	0	4
Acocanthera solingeri	0	0	0	0	0	0	0	0	2		2	0	3	0
Ficus thoningii	0	0	0	0	0	0	0	0	1	1	0	0	1	0
Ficus sp.	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Rhus natalensis	0	0	24	33	0	0	0	0	0	11	0	29	14	16
Olea africa	0	0	4	1	0	0	0	0	0	0	0	0	0	1
Doviarykaffra	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Sandal wood	0	0	11	2	0	0	0	0	0	0	0	0	0	0
Euclea divinorium	0	0	1	33	0	0	0	0	0	0	0	0	13	1
Tarchonanthus	0	0	0	13	0	0	0	0	0	0	0	0	30	25
Euphorbia candelabrum	0	0	0	0	0	0	0	0	0	0	0	0	0	40
Euphorbia tiruccali	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Euphorbia sp.1	0	0	0	0	0	0	0	0	0	0	2	0	0	20

Species	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	Plot 9	Plot10	Plot11	Plot12	Plot 13	Plot14
Cletandrus barbatus	0	0	0	0	0	0	0	0	0	0	0	0	20	5
Dombeya	0	0	0	0	0	0	0	0	0	0	0	0	17	25
Cusonia africana	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Teclea	0	0	0	0	0	0	0	0	0	0	0	0	5	0
Other 1	0	0	1	39	0	0	0	0	0	0	0	0	15	0

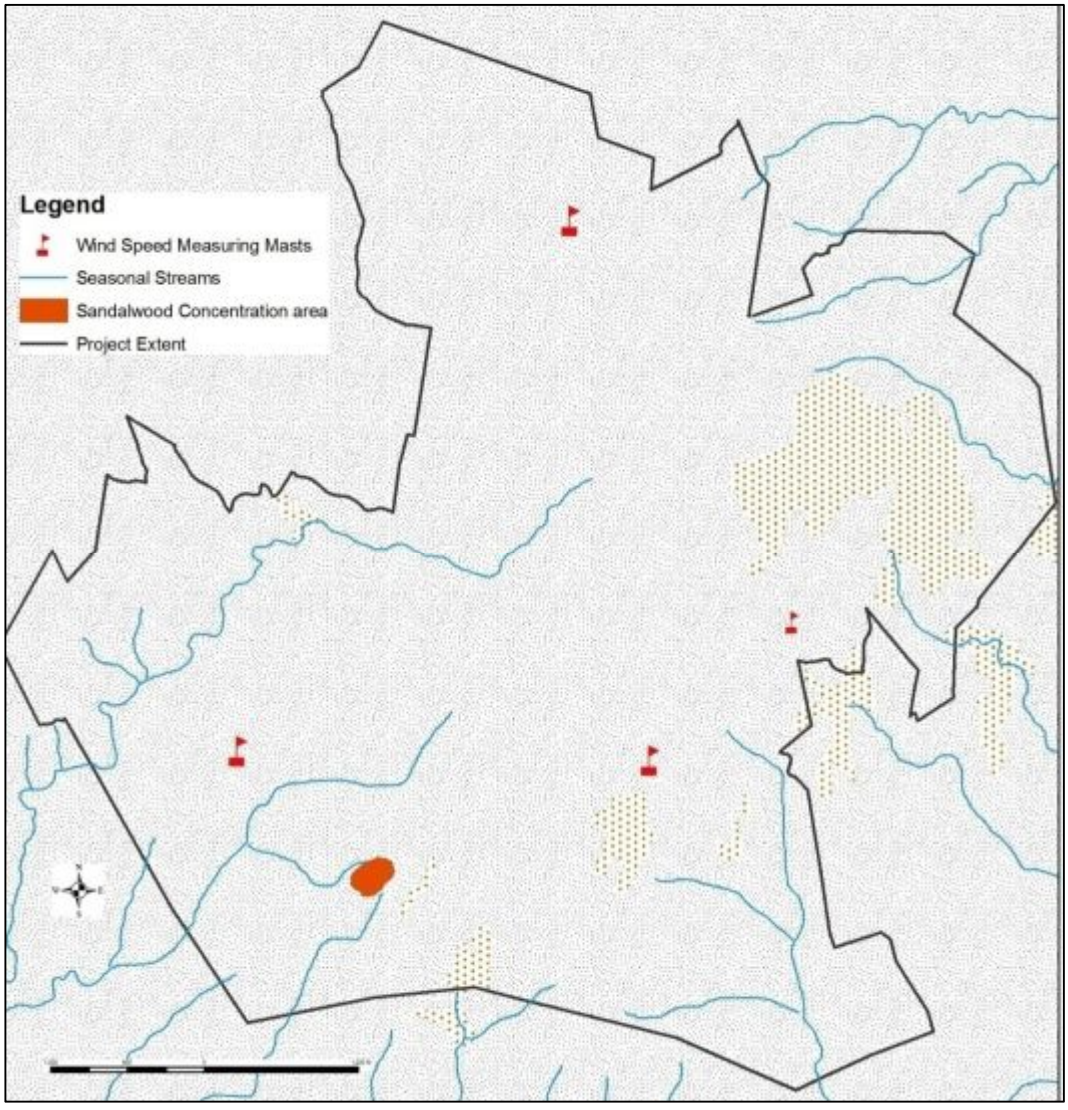
Figure 10: Distribution of sampling plots in Kipeto area



4.6.2.1 Priority plant Species

These are plant species that are given special attention at international and/or national levels. Only one plant species was recorded in Kipeto occurring in an isolated area but mixed up with other plant species. *Osyris lanceolata* is a plant species that is locally endangered due to its value in fragrance industries that makes it a commodity of trade. It was very rare in occurrence in the area; it was not recorded in any of the sampling plots or transect but outside the areas while making general observation of plant species.

Figure 11: Location of priority plant species in the Project area



4.6.3 Landcover changes and sensitivity

Landcover change analysis was undertaken for Kipeto area. This was a subset scene from an Ortho-rectified landsat scene path 168 and row 61 of February for scene for 1987, 2000 and 2005 acquired from the Global Land Cover Facility (http://glcfapp.glcf.umd.edu). Generally, February is one of the driest months in Kajiado and this would provide a clear vegetative reflectance eliminating deceptions from annual plants. Bands 4, 3, 2 of Landsat images were used to composite images. These bands can be used, for instance band 4 for showing vegetation species and biomass content, band 3 for chlorophyll absorption/plant species differentiation and biomass content, and; band 2 for chlorophyll reflectance peak/vegetation species mapping and vegetation stress.

Vegetation covers were broadly classified as:

1. Grasses and Herbs: This represented dominant grass cover with substantial covers of herbs and scattered short shrubs.
2. Bare soils: It is represented by bare soils, rock outcrops, and open cultivated areas
3. Scattered Acacia Woodland: *Acacia* predominate the woodland; however, other tree species are represented in the group.

Landcover has changed over time in Kipeto area as shown by landcover map generated from landsat images. The scattered Acacia trees/shrubs were observed within the proposed project extent in the year 2005 (fig.11) and 1987 (fig.13); while year 2000 (fig.12) had no distribution of the cover. However, grass and herbaceous cover dominated most of the area in year 2000. The absence of observed *Acacia* distribution in the area could be attributed to harsh weather condition such as drought that might have dried most of trees in the area. Tree covers have occurred in the western side of Kipeto on the ridge where the Rift Valley escarpment falls in all the years; however, year 2000 had very sparse covers of the tree covers. Dynamics of landcovers is shown on maps in fig 14 and 15with an explanatory legends.

Figure 12: Landcover for the year 2005

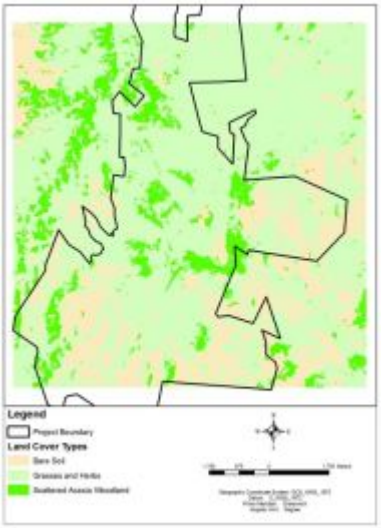


Figure 13: Landcover for the year 2000

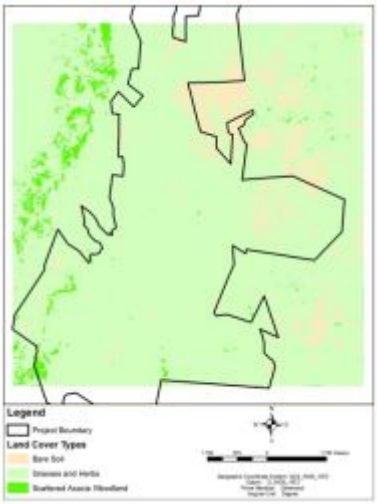


Figure 14: Landcover for the year 1987

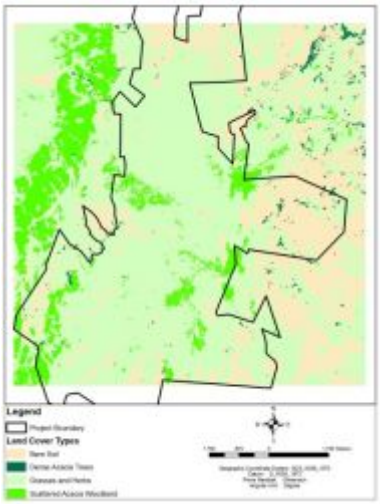


Figure 15: Map showing land cover change detection between years 2000 and 2005

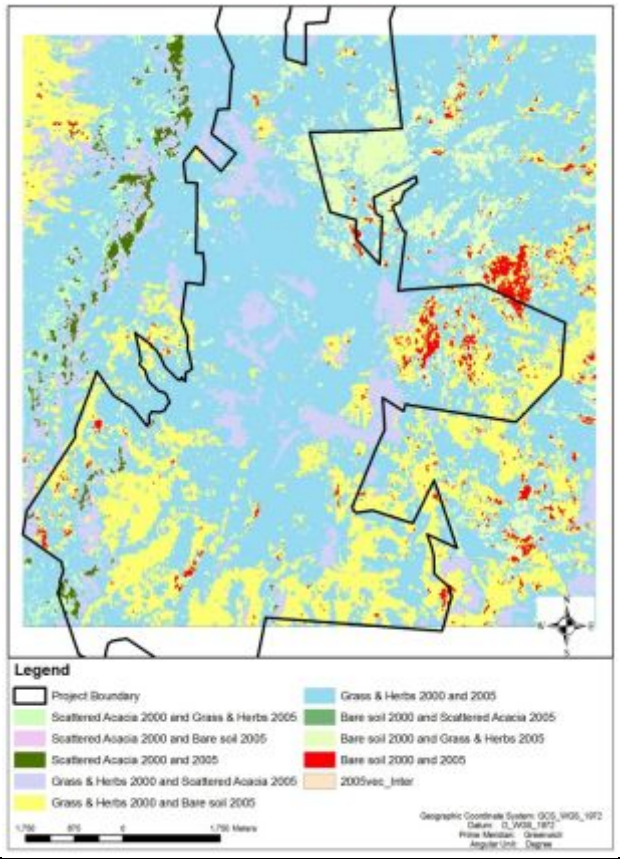
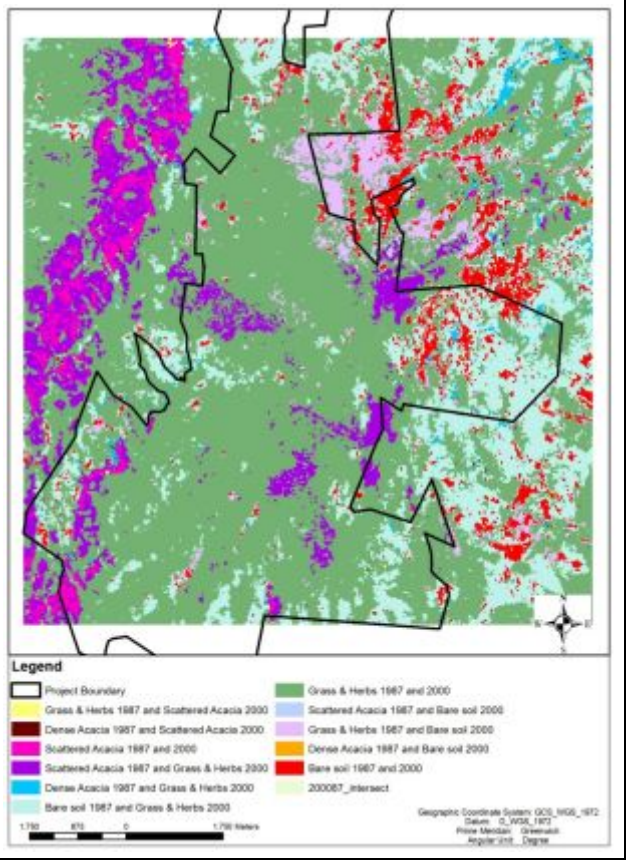


Figure 16:Map showing land cover change detection between years 1987 and 2000



4.7 FAUNAL SURVEY

4.7.1 Mammal Survey

Thomson gazelle are wide spread in the plain areas with grasses in Kipeto. During wet season when grasses were abundant, large population occurred near flocks of Zebra. However, during dry season they were widespread occurring in population of 2 -5 individuals. Zebra were observed in open grasslands and bushes with high grass cover during wet season but dry season observation spotted the population in the bushes and woodland areas towards river valleys throughout the survey.

Dik-Diks were distributed in bushland in Kipeto throughout the wet and dry seasons. They specialized in bush/woodland habitats. African Hare is also distributed all over Kipeto plains and valleys.

Figure 17:Herd of Zebra grazing in Acacia woodland

Figure 18:Thomson gazelles at the horizon

4.7.2 Movements of mammals

The common species among the group were Zebra and Thomson Gazelles. During wet season, the animals were observed dispersed in the plain. Most of gazelles were observed near the groups of Zebra. During dry season they graze very near to or inside bushes. Buffaloes are normally observed by locals during dry seasons. During day time, they occur in the valleys and night they move up the plain grasslands to graze. The valley provide migratory route for buffaloes from Kitengela areas to Lower Kajiado areas near L. Magadi as the locals account. Generally movements of mammals are northeast-southwest directions. Thompson gazelles can disperse widely in the area than Zebra because they are not restricted much by constructed fences in the area.

Figure 19: Map showing potential ranging areas for various species in Kipeto

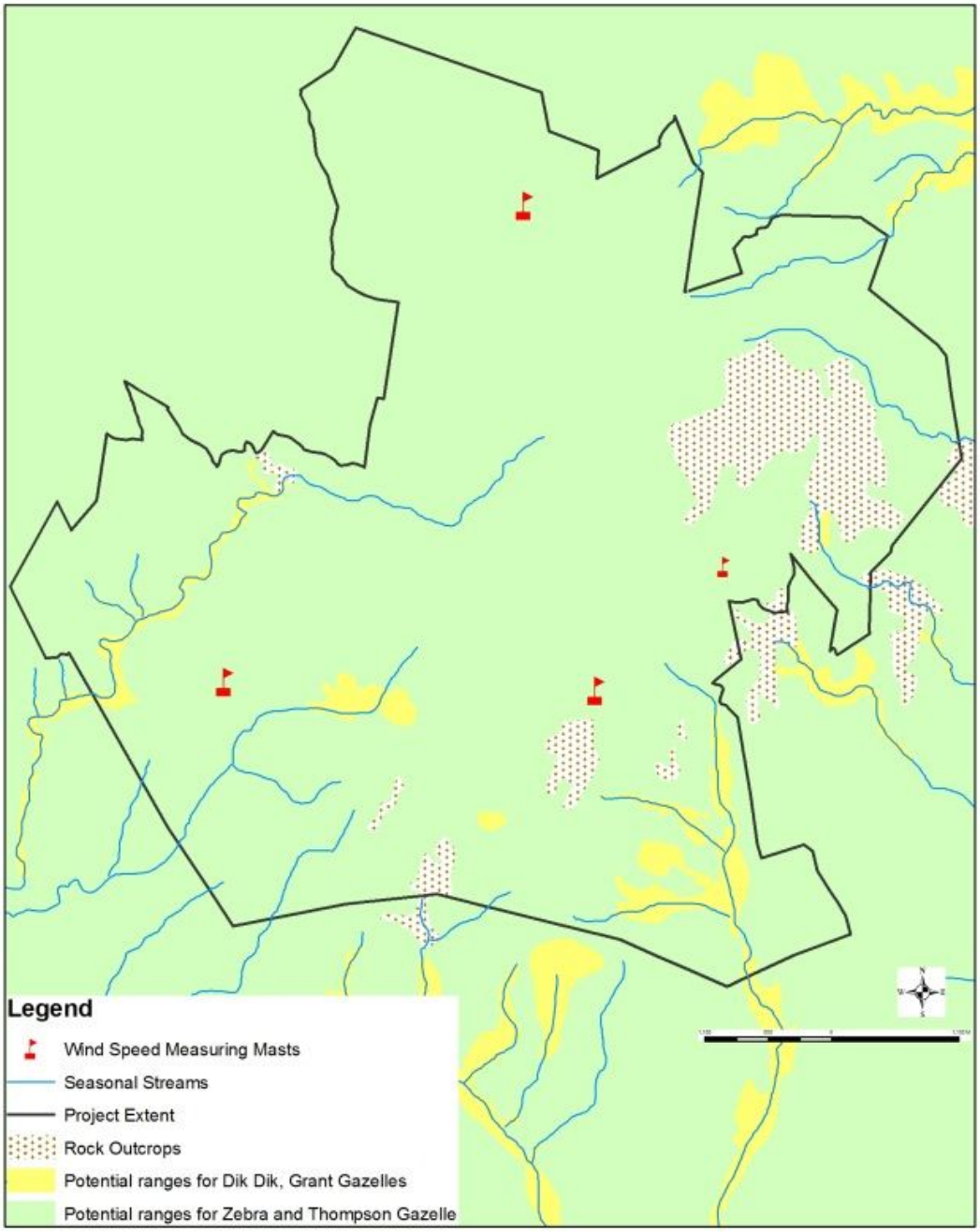
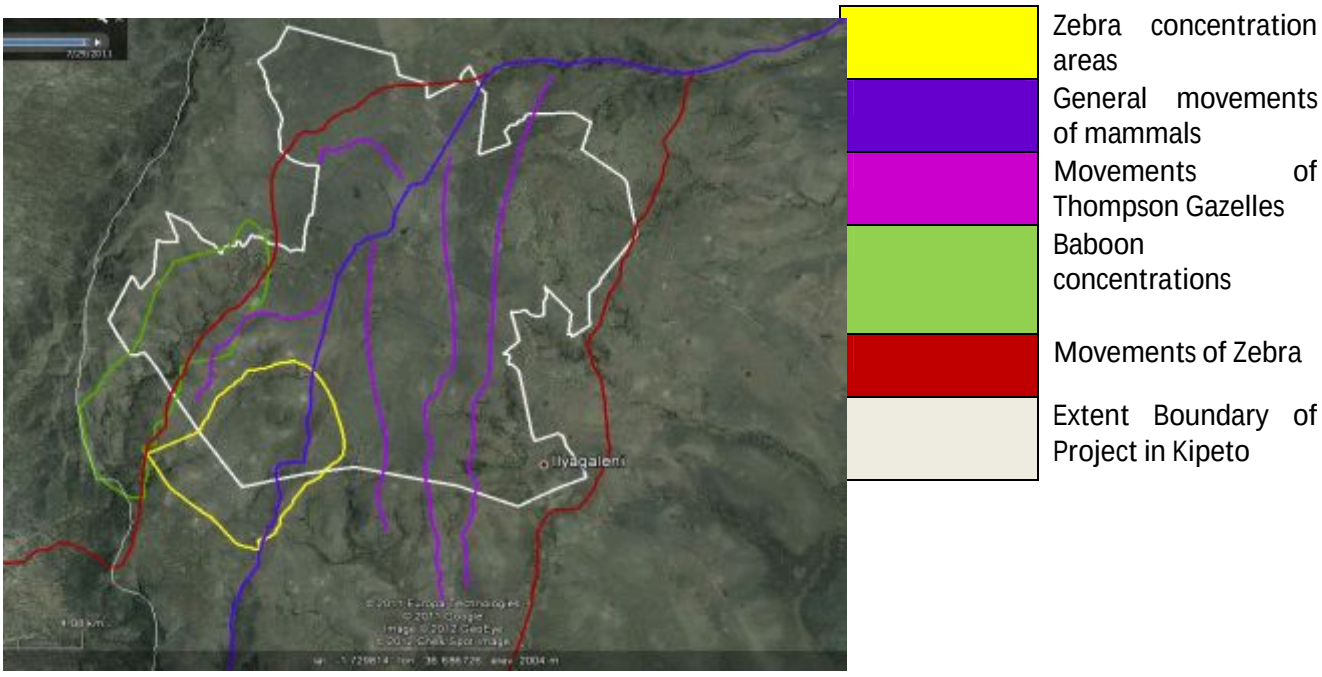


Figure 20: General movements of mammal species in Kipeto area



4.8 Herpetofauna

Taxa that were recorded were snakes, geckos on tree barks and on rocks, frogs were observed in the wells and seasonal streams. This group was not easy spot. Information where they are normally seen was useful in the survey.

Figure 21: A young Cobra snake killed by Maasai pastoralist

4.9 Insect Pollinators

The survey during dry season observed great changes in occurrence and distribution of insect pollinators. There were very short grasses in Kipeto and in some places there were bare soil and stony surface were exposed. Most of the shrubs in the plains had lost their leaves; except for the *Acacia drepanolobium* which had its leaves intact in the period. In the seasonal valleys occurred shrub species with green leaves partularly *Carissa edulis* bushes and the flowering *Acacia nilotica*. These conditions generally determined the distribution of the insect pollinators and abundance across Kipeto landscape.

During wet season survey 25 species were observed across the landscape. Three species of butterflies *Papilio demodocus, Dixeia pigea,Dixeia spp., Charaxes zoolona* were recorded in bush and woodland areas occurring in or near the riparian areas. About five species were recorded in overlaps of grassland and bush/woodland (2-20 % bush/woodland). In bush and woodland (20-40% bush/woodland) areas about 13 species were recorded. While three species were recorded in bushland/woodland (20-40% bush/woodland) and grassland near bushland/woodland (2-20 % bush/woodland).

Out of 25 species recorded during wet season only five species were realized during survey in dry season. *Zizula hylax* was recorded in grassland (0-2 % bush/woodland) and bush/woodland (2-20 % bush/woodland). *Colotis aurigineus,Colotis antevippe,Colotis evagore* was restricted to bush and woodland areas (2-40 % bush/woodland). While *Dixeia pigea* was restricted to bush and woodland areas (20-40 % bush/woodland) in or near riparians.

Figure 22: Images of some Butterfly species observed in Kipeto area

Zizula hylax (Courtesy of Wikipedia)

Azanus jesous (Courtesy of Wikipedia)

Colotis aurigineus (Courtesy of Wikipedia)

Colotis antevippe (Courtesy of learnaboutbutterflies.com)

Colotis evagore (courtesy of biodiversityexplorer.org)

Papilio demodocus

4.10 Human, Livestock and Wildlife Interactions

Wildlife prefers areas with low concentration of human settlement. They tend to avoid areas that are intensively used by humans and their livestock. Generally, livestock-wildlife interactions are affected by the number of the population in the area. This is because of the direct impact the number of animals has on total food, water, cover, and space. The impact varies depending on the degree of competitive overlap among certain species and their associated behavioural traits. Some studies have shown that when stocking rate of livestock increases, number of wild herbivores decreases. Magnitude of decline also depends on the mix of livestock species present in the stocking. For instance decline have been observed in numbers of Deer in pastures stocked with sheep and goats than those stocked with cattle. Decline in population is largely attributed to greater dietary overlap between sheep, goats, and white-tailed deer (Bryant et al., 1979).

The local community living in Kipeto area keep cattle, sheeps and goats that interact with the common wild-herbivores such as Zebras and Thomson gazelles in the landscape. Cattle and Zebras have most of their diets overlapping. This is also observed with the goats/sheeps and Thompson gazelles. Changes in livestock population in the area would possibly affect wild-herbivore population distribution in the wider landscape. Wild-herbivores, however have wider range of dispersal compared to livestock which are restricted.

4.10.1 Sensitive Habitats

Most of wood trees and shrubs are common in the valleys (riverine habitat). Large *Acacia* trees predominate the valley floor while mixed woody and shrub species occur on the flanks of the valleys. These areas are habitat to diverse species of birds, mammals and insects. During dry seasons, riverine areas provide refuge to most of the animal species. Most of the Zebras are observed near or in the woodlands, which predominate the valleys. The valley areas also provide inter-migratory route for mammals including baboons, buffaloes and carnivorous mammals from lower plain lands to higher plain lands of Kipeto area in wet and dry seasons.

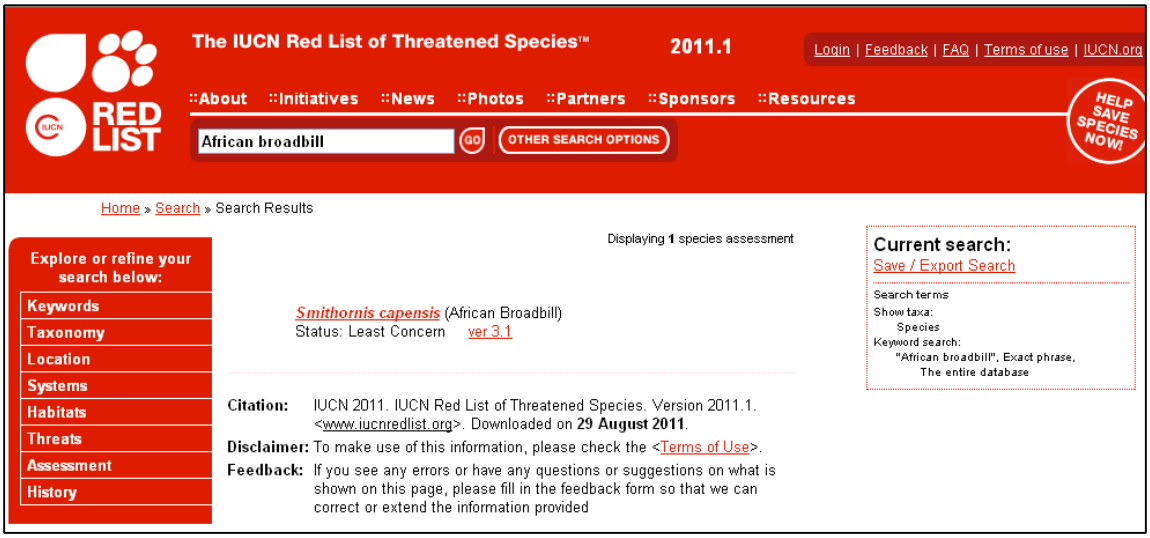
The valley areas are considered sensitive due to the biodiversity it supports throughout the dry and wet seasons. Bird survey in the area indicates most of bird movement occur within the valleys.

Figure 23: Comparison of riverine (valley) woodland habitat with the grassland adjacent to the valleys

4.11 Analysis of conservation status: The IUCN Criteria

The search engine for the IUCN Red list of threatened species (Fig.21) was used to determine conservation status of the species. There are different categories of conservation status of species and are described in the IUCN red list data. These categories include Extinct, Extinct in the Wild, Critically Endangered, Endangered, Vulnerable, Lower Risk, Data Deficient and Not Evaluated. Names of species were entered in the IUCN Red list search engine for verification. Conservation statuses are indicated for each species in biodiversity section below.

Figure 24: Search engine for the IUCN Red list of threatened species



According to the IUCN Red List a species is EXTINCT (EX) when there is no reasonable doubt that the last individual has died, or; EXTINCT IN THE WILD (EW) when it is extinct in the wild and it is known only to survive in cultivation, in captivity or as a naturalised population (or populations) well outside the past range; CRITICALLY ENDANGERED (CR) when it is facing an extremely high risk of extinction in the wild in the immediate future, as defined by any of the criteria (A to E in the IUCN Red List Categories); ENDANGERED (EN) when it is not Critically Endangered but is facing a very high risk of extinction in the wild in the near future, as defined by any of the criteria (A to E in the IUCN Red List Categories); VULNERABLE (VU) when it is not Critically Endangered or Endangered but is facing a high risk of extinction in the wild in the medium-term future, as defined by any of the criteria (A to E in the IUCN Red List Categories), and; LOWER RISK (LR) when it has been evaluated, does not satisfy the criteria for any of the categories Critically Endangered, Endangered or Vulnerable. Species included in the Lower Risk category are separated into three subcategories:

1. Conservation Dependent (CD). Taxa which are the focus of a continuing taxon-specific or habitat-specific conservation programme targeted towards the taxon in question, the cessation of which would result in the taxon qualifying for one of the threatened categories above within a period of five years.
2. Near Threatened (NT). Taxa which do not qualify for Conservation Dependent, but which are close to qualifying for Vulnerable.
3. Least Concern (LC). Taxa which do not qualify for Conservation Dependent or Near Threatened.

A species is DATA DEFICIENT (DD) when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status. Lastly, a species is NOT EVALUATED (NE) when it is has not yet been assessed against the criteria.

5 IDENTIFICATION OF RISKS AND POTENTIAL IMPACTS

The project will have several activities that are potential risk to biodiversity of Kipeto area. The project activities are outlined according to the phase of the project development. The first stage includes construction phase, followed by operation phase and decommissioning phase. Risks on biodiversity are anticipated mostly during the construction and operation phase. The potential risks associated with project activities include:

- Clearing of vegetation and land for construction
- Construction of access roads
- Operation of vehicles and machines/equipment
- Anchoring of turbines
- Placement of underground cables linking turbines
- Establishment of borrow and spoil areas
- Storage of materials for construction
- Running of turbines

5.1 Description of potential impacts

Whenever there is a project development, potential environmental impacts are foreseen in respect to the temporal and spatial scale of the project. It is important to have this in mind in order to address necessary issues. Talking of potential impacts, potential risks cannot escape mention, obviously related to the nature of project activities. Project activities would have varying magnitude of impact on various species, habitats and ecological processes. In the context of biodiversity, ranges of entities are of concern to this survey. These include impacts on floral and fauna species, species of conservation importance and ecological indices (population dynamics, genetical variability). Impacts on sensitive habitats are particularly of concern due to their fragile and vulnerability to extreme incidences.

5.1.1 Impacts on terrestrial vegetation (grasslands and woodlands)

Grass cover comprises the largest among vegetation cover in Kipeto area. These are areas utilized for grazing by livestock. Grassland provides cover, forages, and habitats for various species. Development of projects in the area is a potential threat to the grass species and ecological roles they serve in the area.

Functional habitat size: Grasses are easily affected by trampling by vehicles, clearing of vegetation for road construction and anchoring of the turbines. Normally in areas that experience dynamic climatic conditions, grass species diversity, biomass and cover are affected. Most of wild-herbivores and insects depend on the savanna-grassland for food and cover. Kipeto area experiences changes in climate pattern, especially related to the long and short rains.

Impact on ecological processes: Savannah-woodland is currently threatened by clearing for settlements, agriculture and other development projects. It plays important role in providing habitat for wild-animals such as birds and mammals. Certain species are specifically found in the savannah-woodland. The *Acacia* species form large part of the woody tree species in Kajiado area. The species is particularly suitable for growth in the dry land due to the adaptation to seasonal droughts. Their distribution in the area is affected by dispersal of animals in the plains and other agents.

Due to dynamic nature of the savannah, projects that cover large spatial extent may threaten survival of the vegetation and ecological services they offer. Construction of infrastructures for the project development may result in loss of vegetation at local or extensive areas depending on the size of the project. Consequently, conservation status of the habitat might change negatively. Areas that have not been affected might also be vulnerable to future disturbances such as climate change, wildfires, agricultural developments and others. Under this circumstance, animal species that depend on savannah habitats would be affected.

Change in species diversity/composition: Clearing of vegetation and operation of tracks normally provide ways for alien invasive species, which are brought on site by trucks that acquire them from far places. Roadsides of most newly constructed roads are invaded by invasive plants or opportunistic species such as *Datura stramonium* and *Parthenium*. Also, the area has *Acacia niloticus*, which is considered invasive and can take over other indigenous *Acacia* species.

Impact of air quality: Earth movers normally generate a lot of dusts. Operating machines also produces exhaustives from the engines in the form of nitric oxide (NO) and nitrogen dioxide (NO2) that are the most important phytotoxic pollutants. Traffic exhaust emissions have negative impacts on plant physiology, biochemistry, phenology and growth.

Impacts on surface runoff: changes of drainage will be potentially caused by construction of roads and channels in the area. This affects natural supply of water over the landscape and erosion of soil.

5.1.2 Impacts on sensitive habitats

Ecological processes and Species diversity: Sensitive habitats comprise areas that contain unique cover of floral species (such as endangered species) and vegetation mosaic that support animal diversity throughout the dry and wet seasons. In addition, livelihoods of the locals depend on it. During wet season, wild-herbivores are widely dispersed in the area including grazing livestock. However, it was evident during dry season that valleys remain the only areas with substantive shrubs that provide feeds for browser animals such as grant gazelles and goats. Normally, the valley areas support a diverse species of birds during dry seasons due to the substantial amount of fruit they store. Within the bottom of the river valleys, isolated wells of water exist supporting wildlife, livestock and some locals with water for domestic activities.

Impact on functional habitat size: Construction on sensitive habitats will affect negatively the system capacity to support ecological services. Project activities such as clearing and excavation can contribute to reduction of size of the habitats. Ultimately, this might render the habitat vulnerable to natural forces and exploitation of resources by the local community. Endangered species, however, occupies small area in the potential project site. Sometimes clearing for access roads or construction of turbine anchors would possibly lead to total or partial loss in the system.

Impact on surface runoff: Changes of runoff flow volume and direction in riverine areas can potentially reduce capacity of the system to hold surface soil leading to soil erosion. Roots of trees and shrubs that anchor on the top soil might be affected in the area.

Habitat and genetic diversity: Clearing and excavation can potentially affect habitat diversity causing fragmentation of habitats. Interference with habitat connectivity normally affects gene flow within population of a species.

5.1.3 Impacts on Priority Plant Species

These species are essentially the endangered and threatened plant species. Unlike animals, plant species are very susceptible to project activities due to their immobility. Destruction of their habitats contributes to loss of plant species. Generally, constructions lead to localized damage to individual or localized population of plant species. Most of threatened plant species are rarely seen. This implies that loss of individuals or population can lead to direct change in the conservation status of the species. Potential consequences of the project development may be:

- Fragmentation of population of the affected plant species;
- Reduction in size of area occupied by the species
- Loss of genetic variations within affected species

During the survey, one species of plant listed under priority species of conservation concern to Kenya was recorded in the project site. This is the East African sandalwood (*Osyris lanceolata*), which is covered by the Kenya Wildlife Service in conservation of priority species (www.kws.org/research/priority_ecosystems.html).

O. lanceolata has the ability to regenerate through seeds, rootstock and coppicing; however, regeneration through rootstock is most common.

The tree is harvested in Kenya and exported through various undisclosed routes to Tanzania. After value addition (semi processing), the products are re-exported to Indonesia, India, South Africa, France, Germany and eastern Asia countries for the fragrance and pharmaceutical industry. Currently, the government of Kenya is fighting the trade on O. *Lanceolata* due to its demand for fragrances and pharmaceuticals. This protection will remain in force for the next five years before review.

O.lanceolata occurs in pockets but widely distributed in the country. The tree normally occurs on rocky ridges slopes and margins of dry forests and in thickets. *O. lanceolata* grows slowly and they are semi-parasitic plant that has roots associated with the host plants.

Destruction of the plant by clearing or uprooting would therefore affect their regeneration. Also, destroying other plants might affect them since their roots depend on other plant roots. Since the plants are found in pockets, clearing of such areas can completely destroy the population.

5.1.4 Impacts on Insect Pollinators

Status of the insect pollinators in Kipeto area will depend on the condition of the habitat. These include bees and butterfly species that depend on various habitat types and in particular certain vegetation types.

Distributions of Insect Pollinators: the flowering herbs, shrubs and trees affect distributions of the insect pollinators. Some of the pollinator species are specialized to habitats and/or localised to an area. In this case, some might not of the species might not use the wider connected landscape.

Disturbance of the habitats by the project activities might affect life activities and behaviours of the pollinator species. Some of the insects can fly long distances over several habitats. These particular species might not be affected by the project activities compared to localized species.

Destruction of the vegetation potentially culminates in threat to insect pollinators populations since they rely on trees, shrubs, herbs and grasses as their habitat, for food, breeding areas and shelter. Normally Kipeto area dries up during dry season such that grasses are completely dead, only straws can be seen. Most of bushes and woodland areas remain without leaves except for trees in the riparian areas (seasonal streams) that survive the harsh condition. Notably greens are the *Carissa edulis* that could be observed in the valleys with some flowering and others with fruits. The pollinators are hardly observed in the plain land areas since there are no grasses and herbs to rely on for food, and shelter against strong wind blowing over the area. The riverine areas, therefore, serve as important refugia for the insect pollinators. Destruction of vegetation will limit refugia habitats for the group hence their population.

Ecological processes (pollination): Insect pollinators are substantiated by the role in pollination service in an ecosystem. The riverine (refugia) provide habitat and foraging areas for insect pollinators. These areas, therefore, act as a source of pollinators to farms and other habitats for pollination process throughout the year. Destruction of such areas would reduce their roles in the ecosystem.

5.1.5 Impacts on Mammals and their movements

Project development will potentially affect activities and behaviours of mammal species. The species depend on the area for habitats, foraging grounds and migration during dry season. Some of the mammals prefer woodlands or bushlands, riverine, grasslands and rocky areas. Activities leading to interference of movements of the animal are viewed as adverse to the species.

Impacts of noise: Generally, during the construction of turbines there will be movements of vehicles, noise produced by vehicles and construction equipments. Literature accounts detrimental effects that noise can have on animals. This includes, risk of death, changing delicate balance in predator or prey detection and avoidance. Also, it potentially interferes with the use of sounds in communication in reproduction and navigation. Other than these, noise can cause reduction of use of habitat.

Impact on movements: generally, wild animals do not prefer coming near active human activity areas. They keep off those areas in order to avoid conflict with humans. Some structures constructed can potentially create barrier to movement of animals in the area. Use of flood lights keep off most of wild animals at night. Movement would be affected mostly during construction phase of the project. However, it is important to note that most of the area is already fenced affecting movements of large mammals in between the plots. Most affected mammal herbivore is the Zebra that are now observed in plots with grasses and bushes not fenced or which their fences are damaged. Vehicle movement can potentially cause road kills on mammals especially at night.

5.1.6 Impacts on Herpetofauna

This group comprises animals that mostly crawl or jump on the ground. They will be affected mostly by frequent movement of vehicles. Some of them reside in burrows that will potentially be affected by excavation of surface soils.

Impact on movement of species: movements of the animal species can be restricted potentially by road features. Where species are able to move they however get exposed to road kills. Animals like snakes which are perceived to be dangerous, are killed on spot.

Impact on species and population genetic diversity: project development would potentially cause disconnection of the habitat affecting enrichment of species diversity in the system. Limitation of interaction of species population potentially affects genetic diversity.

6 ASSESSMENT OF IMPACTS

Impacts on biodiversity are analysed with respect to construction and operation phase of the project. These are discussed in relation to impacts associated with the activities of the components of the project. These components include:

- Wind turbines
- Substation
- Underground cables between turbines and linking turbines to internal substations
- Access roads to site and internal access roads

Generally the nature of construction of wind turbines, internal substation and installation of underground cables involves clearing of vegetation and excavation of soils or breaking rocks to create foundations. Their impacts on the environment depend on the location with respect to unique landcover characteristics of habitats. The potential impacts of construction of wind turbines, internal substation, underground cables between turbines and linking turbines to internal substations and access roads to site and internal access roads are discussed on various aspects of the environment.

6.1 Impacts during the construction phase

6.1.1 Impacts on terrestrial vegetation (grasslands and woodlands)

Impact on functional habitat size: up to 67 wind turbines will be constructed in Kipeto area. Each foundation will take an estimated area of 20 m x 20 m of the terrestrial vegetation. Thus, an estimated 3 ha of the area will be excavated for construction of the wind turbines besides the area not estimated for the construction of internal substation and underground cables. The general size of the habitat (area) to be affected is less than 1 % of the overall project area. However, negative impacts can be potentially be realized when functional areas, for instance areas with bushes and woodlands are destroyed. This would reduce its function to biodiversity.

Impact on ecological processes: During operation phase of the project, the components will be manifested in different ways. The structures will potentially affect some ecological processes such as dispersal of plant propagules. Normally, seed dispersal in the area is initiated by herbivores (wild animals and livestock) which eat plant fruit and deposit them with their droppings. Further dispersal is done by runoffs that spread the seeds in the wider landscape. The two agents act to ensure distribution of plant species in the area. Roads would act as barrier to seeds dispersal by runoffs over the wider landscape. If movement of the animals would further be restricted then, some areas would be isolated from recruitment of species population. Some seeds from grasses and shrubs fall down close to the parent plants and are easily moved by runoffs to near or far places. Dispersal of seeds of grasses and Acacia are primarily initiated by herbivores and later spread more by runoffs once they are dropped by animals.

Impact on species diversity: Operating vehicles are potential agents of seeds of plants. Their wheels normally trap mud or dusts that potentially carry plant seeds. This could be *seeds of invasive, opportunistic or obnoxious species* that would grow on road sides when dropped. The current invasive species that are associated with road constructions are the *Parthenium* and *Datura stramonium*.

Impact on plant species population: Construction activities such as clearing of vegetation would reduce plant population in the area of layout design. The area will take some period to regenerate, however excavation destroys completely plant propagules and make the area incapable of regenerating same species. New species (pioneer plants) would initially dominate destroyed areas before others set in. Some areas will be occupied by soil dumps temporarily before they are transported for dumping elsewhere. Soil dumps will potentially cover most of plant species. Impact on the plant population will depend on how long the soil will stay there. However, soil dumps can physically cause breakage of plant stems. When plants are smothered by soil dumps, they get deprived of oxygen and sunlight, and eventually they die and decompose. This will affect only plant species on areas where construction takes place.

Impact of dust generation: Excavations of soil normally turn over soils that produce significant amounts of dusts. Some of the dusts have pathogens that can affect plant leaves when moisture builds up in the atmosphere. Dusts would potentially interfere with the absorption of sunlight by plant leaves, which would reduce the rate of photosynthesis. Plants occurring near the road would be affected most because they receive more dust than those further away from construction areas. These could have potential adverse effects in the growth of plants.

Construction plant and equipment uses diesel fuel in their combustion engines. Exhaust emissions from the engines have air pollutants that potentially affect plant growth. In terms of effect on plants, nitric oxide (NO) and nitrogen dioxide (NO_2) are the most important phytotoxic pollutants associated diesel exhaustion. However, trace amounts of other nitrogen-containing compounds such as nitrous acid (HONO) and nitrous oxide (N_2O) will be present in vehicle emissions. During combustion, other pollutants, including sulphur dioxide (SO_2) and volatile organic compounds (VOCs) are emitted, together with carbonaceous particles from incompletely burnt fuel droplets (Colvile et al., 2001). Some findings of studies have released negative effect of traffic exhaust emissions on plant physiology, biochemistry, phenology and growth. Traffic-derived pollution has been responsible for stress in urban environments, with important implications for plant performance and the health and sustainability of urban ecosystems (Honour, 2009).

It is, however, anticipated that there will be minimal operations of vehicles and machines in the area. Operation of wind turbines, internal substation and underground cables will not affect air quality.

Impacts on surface runoffs: Construction will potentially change geomorphology and gradient of the terrain that influence drainage system in the area. Runoffs in the project area depend on the geomorphology and gradient of the terrain. This also affects runoff flow direction and quantity. Also, residential time for water in the area will be potentially affected. In some places, water might stay for long while others it might be drained very fast to allow passage by vehicles. When large quantities of runoffs are directed in one drainage channel, its erosivity increases causing more erosion than before. This might increase sedimentation in drainage systems and surface water reservoirs.

Impact during Construction Phase

Unmitigated impacts on terrestrial vegetation (grasslands and woodlands) during Construction Phase	
Magnitude of impact	3
Geographic extent	2
Duration of impact	2
Frequency of activity	3
Frequency of impact	3
Result	Low (-42)

Comments/mitigation

Most of the vegetation species are of least concern to conservation in the IUCN list of threatened species.

- Where necessary, avoid destruction of trees and bushes.
- Alternatively, areas that would be cleared of vegetation should be allowed to regenerate.
- In order to avoid dumping of excavated soils during construction of wind turbine foundations and associated infrastructure/roads, soils should be loaded immediately on trucks for carting away. This will avoid smothering of vegetation by soil dumps.
- Construction during extreme dry weather period should be reduced. If not, water sprinklers should be used whenever earthworks are undertaken to reduce dusts released and extent they travel.
- Construction should take place when long or short rains are subsiding in the area. This will avoid uncertainties associated with runoffs. Constructing foundations and roads should not be conducted during extreme dry season as this will affect structural capacity of soil to resist erosion during subsequent rainy season.
- Stockpiles of soil should be reduced/avoided in order to prevent erosion of the stockpiles when it rains in the area. Soil should not be piled on slopes to reduce mobility of soil by runoffs and other disturbances.
- Interference of runoff directions should be avoided or where necessary it should be improved. Where roads traverse the landscape, passage of water should be allowed through by constructing culverts on areas where runoff used to pass. This will sustain normal drainage of water and enhance dispersal of seeds.
- Operating vehicles and other equipment should be cleaned thoroughly to remove sticking soils on wheels and other parts of the vehicle to avoid carrying propagules of the invasive species to the site.
- Soils used for compaction of murram roads should be obtained locally to avoid incidental carrying of propagules of invasive plant species from other places.
- Low speed limit should be adopted for operation in the area to avoid vehicles generating dusts.
- Water sprinklers should be used when intense operation of vehicles is to take place.
- Culverts should be constructed where the road runs across the sloping terrain at an interval of 50 m until where the sloping ends. This will allow passage of water to the other side of the road
- Small water pans or dams (water conservation) should be constructed at strategic points on the terrain to collect water and reduce amount of soil materials eroded away

Mitigated impact on terrestrial vegetation (grasslands and woodlands) during Construction Phase	
Magnitude of impact	2
Geographic extent	1
Duration of impact	2

Frequency of activity	2
Frequency of impact	2
	Very Low (-20)

Impacts during Operation Phase

Unmitigated impact on terrestrial vegetation (grasslands and woodlands) during Operation Phase	
Magnitude of impact	2
Geographic extent	3
Duration of impact	3
Frequency of activity	4
Frequency of impact	3
Result	Low-Medium (-56)
Comments/mitigation ▪ Livestock and wild-herbivores should be allowed to graze/browse over most of the landscape to sustain dispersal and spatial recruitment of plant species. ▪ Interference of runoff directions should be avoided or where necessary it should be improved. Where roads traverses the landscape, passage of water should be allowed through by constructing culverts on areas where runoff used to pass. This will sustain normal drainage of water and enhance dispersal of seeds. ▪ Operating vehicles and other equipments should be cleaned thoroughly to remove sticking soils on wheels and other parts of the vehicle to avoid carrying propagules of the invasive species to the site. ▪ In case of invasion by invasive plant species during operation phase of the project, strategies for controlling the invasive should be deviced, such as uprooting the plants or use of herbicides, for controlling them. ▪ Low speed limit should be adopted for operation in the area to avoid vehicles hurling dusts. ▪ Most of vehicle and equipment operation should be during the offing of rainy seasons in order to avoid encounter of dusts ▪ Water sprinklers should be used when intense operation of vehicles is to take place during dry periods that dust would be generated. ▪ Soil conservation strategies should be adopted in the area to control soil erosion	
Mitigated impact on terrestrial vegetation (grasslands and woodlands) during Operation Phase	
Magnitude of impact	1
Geographic extent	2
Duration of impact	2
Frequency of activity	2
Frequency of impact	2
Result	Low (-20)

6.2 Impacts on sensitive habitats

Construction of turbines, substation and installation of underground cables could potentially have adverse effects on sensitive habitats. It would increase vulnerability of sensitive habitats to other anthropogenic pressure and natural environmental stresses. Areas that are to be cleared could directly or indirectly affect sensitive plant species by physical destruction and/or spatial coverage of sensitive habitats. Sensitive habitats are normally small in area and support ecological services and species, which make them unique in an ecosystem. If layout design for wind turbines and its accessories are laid on the sensitive habitat such as riverine habitats, environmental impact could be significant on the habitat. Construction activities will potentially affect sensitive habitat to support ecological services.

Impact on habitat size: Clearing of vegetation might reduce size of or completely clear standing plant population of sensitive habitats. This, however, is reversible but the rate would depend on the type of plant and the magnitude of impact. Excavation on the other hand will cause irreversible impact on the habitat. It will involve complete removal of top soils with vegetation therein. Some of these areas are small in size such that construction of turbines and roads can create a negative impact on the habitat.

Impact on species population: Species diversity is low in the sensitive habitats like the riverine areas. Destruction of the standing population of plant species in sensitive areas might affect individual population of a species. Some species might be severely destroyed during construction phase than others. Thus, their response to recovery might be slow in the system such that other plant species might displace it.

Impact on surface runoffs: Change of surface runoffs flow direction and quantity in or near sensitive habitats will caused by changing the terrain geomorphology and gradient. Changes of runoff flows and quantity will potentially cause soil erosions in the slopy areas of the riverines. Sedimentation in the bottom of the valleys is anticipated to occur, which will potentially reduce their capacity to hold water for long during dry seasons.

Impact on ecological processes: Sensitive habitats in Kipeto area provide ecological roles to animal species. These include provision of refugia during extreme weather conditions, seed dispersal, food reserves for baboons and insect pollinators; the bottom valley also stores water for long, which is used for drinking by wild animals and livestocks. Other than these, local community derives their livelihood from this system from tree-wood resources. Destruction by clearing, excavation and soil dumping will, therefore, affect the ecological services in long term.

Unique ecological processes occur in the sensitive habitats. Services like seed dispersal sustain the system's plant population. Riverines in Kipeto are disconnected, separated by grassland in the plains. Most of plants that occur throughout the year are dispersed by fruit eating birds that move mostly along the valleys. The operation of wind turbines can potentially affect the movement of birds, which ultimately would affect seed dispersal between the valleys.

The operation of wind turbines and its accessories can potentially cause a diminishing interaction of animal species population interactions between habitats. Once interaction of the habitats is restricted the populations would be locally isolated. Low flying birds that depend on connectivity of bushes/woodland can be affected adversely if most of vegetation is destroyed. This also includes some of the insect pollinators such as bees and butterflies. Some of the species of butterflies fly very low to the ground depending on grasses and small bushes in order to connect to other habitats. Destruction of vegetation would interfere with their flight direction.

Sensitive habitat such as riverines potentially acts as a source of nutrient to aquatic system of streams and subsequent rivers that they pour their waters. Destruction of the vegetation would reduce the capacity of these habitats to replenish nutrients to aquatic systems.

Impact on habitat, species and genetic diversity: Interference with interaction of sensitive habitats through dispersal of plant propagules and movement of animal will potentially affect species and genetic diversity of the area. Existence of diverse habitats with similar functionality will provide the animal species with suitable environment for proliferation. Such habitats are potential reserve for diverse species and population genetics. However, diverse population genetics depend on interactions among populations in different habitat. When connectivity of the habitats is interfered with by the project activities, these populations will be affected in terms of genetic connectivity. Small mammals (rodents), reptiles and crawling insects will be potentially affected by habitat disconnection.

When there is no habitat connectivity, species population will be potentially isolated from others. These species (or population) might be adversely affected by competition for space and food, and predation.

Increase demand for woodfuel is anticipated to increase due to working population. Most of tree species and suitable one for woodfuel such as the *Acacia* and *Euclea divinorium*, occur in and near the riverine areas. Increase exploitation of targeted species for woodfuel would affect species diversity and population in the habitats.

6.2.1 Impacts during construction

Unmitigated Impacts on sensitive habitats during construction phase	
Magnitude of impact	3
Geographic extent	3
Duration of impact	2
Frequency of activity	1
Frequency of impact	4
Result	Low (-40)
Comments/mitigation ▪ Avoid designing turbine construction in sensitive habitats such as riverine areas (valleys). ▪ Avoid piling of soils in the sloping terrain of the riverine habitat since this might cause destruction of the area by smothering and breaking of trees. Piled up soil can also kill vegetation in this area by suffocation. ▪ If destruction will be realised then, local indigenous trees should be planted to compensate loss and to enable undelayed recovery of the system.	

▪ Where necessary, areas that are temporarily affected can be encouraged to regenerate. ▪ Water channels should not be constructed running along the slope. It should, however, be made to incline on the slope. ▪ Development of soil dumps should be avoided on the landscape in order to conserve the physical appearance. ▪ Complete clearance of vegetation should be avoided in order to provide connections for small mammals (e.g rodents), reptiles and crawling insects passage to other habitats	
Mitigated impact on sensitive habitats during construction phase	
Magnitude of impact	2
Geographic extent	1
Duration of impact	2
Frequency of activity	1
Frequency of impact	2
Result	Very Low (-15)

6.2.2 Impacts during operation

Unmitigated Impacts on sensitive habitats during operation phase	
Magnitude of impact	2
Geographic extent	3
Duration of impact	2
Frequency of activity	3
Frequency of impact	3
Result	Low (-42)
Comments/mitigation ▪ Vegetation mosaics should be improved by planting trees to allow animal species to connect to other habitats in the area ▪ Encourage regeneration of plants in the riverine areas	
Mitigated impact on sensitive habitats during operation phase	
Magnitude of impact	1
Geographic extent	1
Duration of impact	2
Frequency of activity	2
Frequency of impact	2
Result	Very Low (-16)

6.3 Impacts on Priority Plant Species

The East African sandalwood (*Osyris lanceolata*) is currently threatened nationally by trade due to its value in fragrance industries. Due to this, the plant is prioritised by the Kenya government for protection against poaching. The species is sparsely distributed in its ecological range; and where it is distributed, it occurs in small population, which is sparsely isolated. Even though the species is not found evrywhere in Kipeto, the design layout of the wind turbines and its accessories, construction activities might incidentally wipe out sparsely isolated population. In addition to the current threat of trade, the species would be affected by construction activities. Livestock grazing have affected growth height of most plants in the area; thus the height of *Osyris lancealata* is affected very much. Increased grazing might therefore, affect the species distribution.

Impact on species population: The priority plant species is Osyris lanceolata that occurs in pockets in the area has species of conservation concern to the country. The operation of the project will have indirect impact on the species. It is anticipated that concentrated areas that have wind turbines and it accessories might not be used intensely for livestock grazing. This implies livestock grazing will increase in other areas. Thus, grazing pressure might increase in areas where the species occur.

Road constructions will open access to the locations of *Osyris lanceolata.* If poachers would know their distribution, the species will be potentially endangered by collections for trade. Normally parts which are used mostly are roots and stems. Collection of the plant would require uprooting of the whole plant. This method of collection affects adversely the regeneration of the species in the area.

Impact on ecological processes: Osyris lanceolata is an indigenous plant species that partially gets nutrients from interaction with other plants. It is, therefore, known to be a semi-parasitic plant. Its occurrence is dependent on existence of other shrubs in order to survive in an area. Any factor that will affect bushes in the area will indirectly affect their distribution in the area. Thus, exploitation of woodfuel and grazing of livestock will potentially affect them.

6.3.1 Impacts during Construction

Unmitigated impact on Priority Plant Species during Construction phase of the project	
Magnitude of impact	4
Geographic extent	2
Duration of impact	3
Frequency of activity	2
Frequency of impact	3
Result	Low (-45)
Comments/mitigation ▪ Avoid construction where distributions of *Osyris lancealata* occurs ▪ The sparse isolations should be protected and fenced off during the construction phase and out of reach to people. This will also encourage their growth to significant heights ▪ Development of soil dumps should be avoided near or on areas with the *Osyris lancealata*	
Mitigated impact on Priority Plant Species during Construction phase of the project	
Magnitude of impact	2

Geographic extent	1
Duration of impact	2
Frequency of activity	1
Frequency of impact	2
Result	Very Low (-15)

6.3.2 Impacts on Priority Plant Species during Operation

Unmitigated impact on Priority Plant Species during operation phase of the project	
Magnitude of impact	3
Geographic extent	2
Duration of impact	3
Frequency of activity	3
Frequency of impact	2
Result	Low (-40)
Comments/mitigation ▪ Livestock grazing should be avoided around the area in order to allow the plants to grow. ▪ Access to the project site should be restricted. Other than the known local people, only authorized persons should be allowed to enter the area. ▪ If possible, their area of occurrence should be fenced out of reach to people and regeneration encouraged.	
Mitigated impact on Priority Plant Species during operation phase of the project	
Magnitude of impact	2
Geographic extent	2
Duration of impact	2
Frequency of activity	2
Frequency of impact	2
Result	Very-Low (-24)

6.4 Impacts on Insect Pollinators

Construction activities will potentially pose a short-term effect on insect pollinator species. Once plants that form a source of food, shelter and cover for the species are affected then, the insect pollinators will also be affected. The impact of construction could be worse on the insect pollinators if activities takes would place during dry season when most plants are dried up.

Impact on distributions of Insect Pollinators: Established roads and turbines will potentially affect distribution of some of the insect pollinators and others. If clearing of vegetation especially in the riverine forests and plain lands this group will be potentially affected. These areas are regular sources of food and cover for the group of species during extreme weather conditions. Roads and other structures will potentially act as barrier to movement of the group, especially species that fly low to the ground and others that crawl on the surface of soil. Breaking continuity of vegetation spread would affect species of butterflies that move close to the ground due to grass/weed covers such as Zizula hylax, Azanus jesous e.t.c. Thus, their connection with wider landscape might be restricted by the barriers, hence their population.

Directions of their movement will depend on the nearest vegetation that they rely on daily for food and cover from predators and extreme weather conditions. During rainy season distribution some insect pollinators were observed in riverine forests and grassland but during dry season only few could be seen in the riverine forest areas. The riverine areas has vegetation such as *Carissa edulis* that establishes flowers and fruits even during dry season; while in the plain grassland vegetation has no leaves. The grasses in the plains dry up completely during dry season leaving most insects with riverine forests as the only refugia.

Impact on ecological processes: Insect pollinators such as bees and butterflies are in varying degree effective in pollinating wild and grown crops. Currently, most agricultural crops rely on pollination services for quality fruit development. Farms that are in proximity to forest or bushes are advantaged in receiving pollinators throughout the year. In Kipeto area, reserves for insect pollinators are the riverine areas where they occur in all seasons. Pollinators such as bees (honey bee) and some butterfly species e.g. Papilio demodocus can travel long distance and over a wider range of altitude to look for food and water. They only visit areas with vegetation covers potential for food and cover. When habitats for the insect pollinators are destroyed by construction they will tend to migrate to areas with suitable environmental conditions. This implies their services will be pushed away from the local area. Lack of insect pollinators in the area will affect potential production of beans and other fruiting crops endeavoured to be grown in the area. Only high flying and long ranging insects can easily evade impacts of barriers by migrating to suitable habitats.

Most of the insect pollinators live for an average of 40 days in adult stage; however few can go up to six months. Most of reproduction takes place during favourable environmental conditions. This might have contributed to variation in their spatial and temporal distribution. Some would move to new areas when environmental condition worsens in the area within their lifespan. Their movement to other habitats enhance species diversity and population gene flow.

Impacts on Insect Pollinators During Construction

Unmitigated Impacts *on Insect Pollinators During construction phase of the project*	
Magnitude of impact	2
Geographic extent	2
Duration of impact	2
Frequency of activity	1
Frequency of impact	3
Result	Very-Low (-24)
Comments/mitigation ▪ Where necessary avoid construction during dry season in the riverine areas to reduce impacts of construction on plants that are relied on by insect pollinators.	
Mitigated impact on Insect Pollinators During construction phase of the project	
Magnitude of impact	1
Geographic extent	1
Duration of impact	2

Frequency of activity	1
Frequency of impact	2
Result	Very Low (-12)

6.4.1 Impacts on Insect Pollinators During Operation

Unmitigated impact on Insect Pollinators During Operation phase	
Magnitude of impact	2
Geographic extent	2
Duration of impact	2
Frequency of activity	2
Frequency of impact	2
Result	Very-low (-20)
Comments/mitigation ▪ Improvement of habitat (vegetation) connections should be enhanced by conserving grasses and bushes that occur in the wider landscape. ▪ The road should be allowed to have natural small growths of grasses to provide attractive passage to the other side of the road. *Zizula hylax* and *Azanus jesous* have been observed on murram roads with small grassed. The species were only observed mostly on road sides of murram roads. Improvement of habitat (vegetation) connections should be enhanced by conserving grasses and bushes that occur in the wider landscape.	
Mitigated impact *on Insect Pollinators During Operation phase*	
Magnitude of impact	1
Geographic extent	1
Duration of impact	2
Frequency of activity	1
Frequency of impact	2
Result	Very-Low (-12)

6.5 Impacts on Mammals

Impacts of noise on behaviours: Initially, noises (sounds) produced from construction machines activities will potentially keep away mammals. Extreme noises disturb mammals and can affect their communications when they interact, also reduce their ability to sense predators or hunt preys. This would affect species that rely on sense of hearing. Observations made on highways especially Naivasha-Nakuru road and Nairobi-Mai Mahiu, Narok road, on large mammals especially Zebras, Gazelles and Baboons also occur at Kipeto realized that they are not disturbed by noises from different types of vehicle. Actually, Zebra and Thompson gazelles graze comfortably; baboons also roam around without disturbance. This is an indication that these animals (observed in Kipeto) would not be affected by noises produced by the operating machines.

During the project operation, noise will be generated by operating wind turbines and occasional moving vehicles. The sound levels generated by wind turbines are, however moderate and regular that will not distract behaviours of the mammal species. However, moving vehicle can potential produce distracting noise when changing gears or moving very fast. However, some population of Zebra, Thompson gazelles and Baboons are observed eating comfortably along Naivasha-Nakuru, Nairobi-Mai Mahiu-Narok highway (roads). They eat with less or no distraction from moving vehicles and noises they produce.

Impact on movements: Mammals (except domesticated animals) are normally sensitive to areas with active human operations. Most of the mammal species fear flood lights or lights from vehicle. These might keep them off from the area potentially affecting their movement and where the graze. Operations of heavy equipment might affect movements of small mammals (e.g. rodents like the ground moles) through tremors they generate.

Movement of animal species across the landscape will potentially be affected. However, it is important to note that some areas in Kipeto are under fences which to some extent affect free movement. The area potentially connect animals moving from the north eastern (south of Nairobi National Park) to Magadi Generally large wild herbivores do not prefer grazing near active human operating structures in the day.

Rodents would be prone to crossing roads and this would endanger them to road kills. Construction of enclosed access roads would cause isolation of small mammals especially the Ground Moles that move below soils. The road would disconnect (isolate) Ground Moles from other areas. This will potentially make them more vulnerable to extreme weather conditions and predators. The mammal species especially Zebra and Thomson gazelles are potentially endangered by road kills by vehicles moving at high speed when they cross roads.

Impact on Mammals during construction

Unmitigated impact on Mammals during construction phase of the project	
Magnitude of impact	3
Geographic extent	3
Duration of impact	2
Frequency of activity	2
Frequency of impact	4
Result	Low (-48)
Comments/mitigation ▪ The machines should be equipped with appropriate silencer to control potentially disrupting noises ▪ Construction activities should be done within a short period to avoid prolonged period of noise and contact ▪ Daily times for starting and ending of operation of machines and vehicle should be restricted to between 8 am to 5 pm daily. ▪ The use of flood lights should be limited especially in areas perceived to be used by the animals frequently	
Mitigated impact on Mammals during construction phase of the project	
Magnitude of impact	1
Geographic extent	2
Duration of impact	2

Frequency of activity	1
Frequency of impact	2
Result	Very Low (-15)

Impact on Mammals during operation

Unmitigated impact on Mammals during operation phase of the project	
Magnitude of impact	2
Geographic extent	3
Duration of impact	2
Frequency of activity	2
Frequency of impact	2
Result	Low (-28)
Comments/mitigation ▪ Improvement of habitat (vegetation) connections should be enhanced by conserving grasses and bushes that occur in the wider landscape. ▪ Potential road kills of large mammals can be reduced by limiting speed to 30 at night and 40 day time to reduce impacts of accidents when vehicle collide on animals also the speed can give drivers lapsing period for braking. ▪ Vehicles should avoid use of full lights at night as this confuses animals while on road and increases chances of accidents.	
Mitigated impacts on Mammals during operation phase of the project	
Magnitude of impact	1
Geographic extent	2
Duration of impact	1
Frequency of activity	1
Frequency of impact	2
Result	Very-Low (-12)

6.6 Impacts on Herpetofauna

Most of herpetofauna species crawl on ground and climb trees. Construction of turbines would potentially destroy their physical habitats and affect their food source which is largely insects. Vibrating machines would scare away the species from construction areas. Some, which live in holes, are potentially affected by the excavation of soils where they occur. Some of the species like toads, snakes, lizards may be trapped in pits before turbines are anchored. This can increase rate of deaths during construction. Some ecological aspects of the group will be potentially affected. These include their movement from one habitat to another and species and genetic diversity.

Impact on movement of species: Established roads break habitat continuity on a landscape. Most of herpetofauna species requires habitat connectivity for dispersal and migration. Road can contribute to exposure of the species to road kills when crossing roads. Some species which are perceived to be dangerous like snakes can easily be by local people when crossing road.

Impact on species and population genetic diversity: Established roads can act as a barrier to species population on either side of the road. Their interactions can potentially be reduced in long-term. Species populations that interact have high genetic diversity than isolated individuals. Spatially connected habitats could have more species diversity than isolated habitats.

6.6.1 Impacts during construction phase

Unmitigated Impacts on herpetofauna during construction	
Magnitude of impact	3
Geographic extent	3
Duration of impact	2
Frequency of activity	2
Frequency of impact	3
Result	Low (-40)
Comments/mitigation ▪ Avoid cutting trees where possible in order to provide them with areas they can use for trapping insect food and habitat. ▪ Excavation of the mounds should be done with a lot of care as some species prefer inhabiting termite mounds as an area for their food source or habitation.	
Mitigated impact on herpetofauna during construction phase of the project	
Magnitude of impact	1
Geographic extent	2
Duration of impact	2
Frequency of activity	1
Frequency of impact	2
Result	Very Low (-15)

6.6.2 Impacts during operation phase

Unmitigated impact on herpetofauna during operation phase of the project	
Magnitude of impact	2
Geographic extent	2
Duration of impact	1
Frequency of activity	2

Frequency of impact	2
Result	Very-low (-20)
Comments/mitigation ▪ Potential road kills of reptiles and amphibians can be reduced by limiting speed to 30 at night and 40 day time to enable drivers to brake as they cross the road.	
Mitigated impact on herpetofauna during operation phase of the project	
Magnitude of impact	1
Geographic extent	2
Duration of impact	1
Frequency of activity	1
Frequency of impact	2
Result	Very-low (-12)

7 ENVIRONMENT MANAGEMENT PLAN

Following the proposed mitigation measures, a management plan is necessary for the project during the construction and operation phase. This will ensure potential negative impacts are controlled. The management plan focus only on environmental aspects that impact of the project would affect significantly. Operation of the project apparently would have significant impact than construction. This is due to long-term exposure of certain activities to the environment. Impacts that were rated medium-high, high and very high are considered in the environmental management plan (EMP).

Potential impact	Project components	Aspects affected	Activity/risk source	Mitigation: Action/control	Monitoring aspect	Responsibility
Impact on terrestrial vegetation	▪ Wind turbines ▪ Internal substations ▪ Underground cables and ▪ Roads	▪ Impact on functional habitat size ▪ ecological processes ▪ species diversity and population ▪ air quality ▪ surface runoffs	▪ Construction	▪ Where necessary, avoid destruction of trees and bushes and allow regeneration of plants. ▪ Avoid dumping of excavated soils during construction of foundation of the structures. This will avoid smothering of vegetation by soil dumps. ▪ Construction during extreme dry weather period should be limited. water sprinklers should be used whenever heavy machines are used to turn soil in order to reduce dusts released ▪ Construction should take place when long or short rains are offing in the area. This will avoid uncertainties associated with runoffs. ▪ Piles of soil should be reduced/avoided in order to prevent erosion by runoffs. ▪ Interference of runoff directions should be avoided or where necessary it should be improved by constructing culverts on areas where runoff used to pass. This will sustain normal drainage of water and enhance dispersal of seeds.	▪ Vegetation cover ▪ Species diversity ▪ Dust levels ▪ Runoff directions and erosions	▪ Project developer ▪ Environmental Officer

Potential impact	Project components	Aspects affected	Activity/risk source	Mitigation: Action/control	Monitoring aspect	Responsibility
			▪ Construction	▪ Most of soils for compaction of murram roads should be obtained locally to avoid incidents of carrying propagules of invasive plant species from other places. ▪ Small water pans or dams (water conservation) should be constructed at strategic points on the terrain to collect water and reduce amount of soil materials eroded away.		
			▪ Operation phase	▪ Operating vehicles and other equipments should be cleaned thoroughly to avoid carrying propagules of the invasive species to the project site. ▪ Low speed limit should be adopted for operation in the area to avoid vehicles hurling dusts. ▪ Water sprinklers should be used when intense operation of vehicles is to take place.		
Impacts on sensitive habitats	▪ Wind turbines ▪ Internal substations ▪ Underground cables and ▪ Roads	▪ habitat size ▪ surface runoffs ▪ ecological processes ▪ habitat, species and genetic diversity	▪ Operation phase	▪ Vegetation mosaics should be improved in order to allow animal species to connect to other habitats in the area ▪ Encourage regeneration of plants in the riverine areas	▪ Vegetation cover ▪ Species diversity ▪ Runoff directions and erosions	▪ Environmental Officer ▪ Project developer
Impacts on Priority Plant Species	▪ Wind turbines ▪ Internal substations ▪ Underground cables and ▪ Roads	▪ species population ▪ ecological processes	▪ Operation phase	▪ Livestock grazing should be avoided around the area in order to allow the plants to grow. ▪ Access to the project site should be restricted. Other than the known local people, only authorized persons should be allowed to enter the area. ▪ If possible, their area of occurrence should be fenced out of reach to people and regeneration encouraged.	▪ Species abundance ▪ Species distribution	▪ Project developer ▪ Local community ▪ Environmental Officer
Impacts on Insect Pollinators	▪ Wind turbines ▪ Internal substations	▪ distributions of Insect Pollinators ▪ ecological	▪ Operation phase	▪ Improvement of habitat (vegetation) connections should be enhanced by conserving grasses and bushes that occur in the wider landscape. ▪ Fish born road pattern should be designed to allow for	▪ Pollination activities of insect pollinators ▪ Diversity and Distribution of	▪ Project developer ▪ Environmental

Potential impact	Project components	Aspects affected	Activity/risk source	Mitigation: Action/control	Monitoring aspect	Responsibility
	▪ Underground cables and ▪ Roads	processes (pollination)		dispersal of insect pollinators to other areas. ▪ The road should be allowed to have natural small growths of grasses to provide attractive passage to the other side of the road. *Zizula hylax* and *Azanus jesous* have been observed on murram roads with small grassed. The species were only observed mostly on road sides of murram roads. Improvement of habitat (vegetation) connections should be enhanced by conserving grasses and bushes that occur in the wider landscape.	pollinator species	Officer
Impact on Mammals	▪ Wind turbines ▪ Internal substations ▪ Underground cables and ▪ Roads	▪ Species behaviour ▪ Species movements ▪ Species population	▪ Construction	▪ Reduce use of flood lights at night ▪ Fish born road pattern should be designed to allow for dispersal of rodents to other areas. ▪ Culverts should be constructed on roads an interval of 50 m to provide underpass for rodents.	▪ Eating behaviours ▪ Movements and distributions	▪ Project developer ▪ Environmental Officer
			▪ Operation phase	▪ Improvement of habitat (vegetation) connections should be enhanced by conserving grasses and bushes that occur in the wider landscape. ▪ Potential road kills of large mammals can be reduced by limiting speed to 30 at night and 40 day time to reduce impacts of accidents when vehicle collide on animals also the speed can give drivers lapsing period for braking. ▪ Speed of vehicles should be controlled (i.e. reduced) in the area to avoid unnecessary distractions.		
Impact on herpetofauna	▪	▪ Movement of species ▪ Species and population genetic diversity	▪ Construction	▪ Culverts should be constructed on roads an interval of 50 m in areas with bushes to provide underpass for species. ▪ Fish born road pattern should be designed to allow for dispersal of reptiles and amphibians to other areas.	▪ Movements and distributions ▪ Species abundance	▪ Project developer ▪ Environmental Officer
			▪ Operation phase	▪ Potential road kills of reptiles and amphibians can be reduced by limiting speed to 30 at night and 40 day time to enable drivers to brake as they cross the road.		

8 CONCLUSIONS

Impact of the project will be realized on environment from various activities of the project components. From the analysis of impact the operation phase of the project will have more severe impact on environment than construction phase. Construction phase of the projects is normally short-term than the operation. The operation phase of the project tends to interfere with ecological processes of the habitat/ecosystem, which can only be released in long-term.

The operation phase of the project has potential to interfere with dispersal of seeds in the area. Through established barriers such as roads plant that relies on runoffs for distance dispersal of seeds might be restricted or redirected to direction of channels. Movements of rodents, reptiles and amphibians, and crawling insects will potentially be restricted by the road cuttings. Normally, road pattern that closes by meeting itself at any point of the road would create an "island". This is occurs when the road isolate part of the landscape from the extensive areas. Mammal species like the ground moles and others rodents can easily be restricted by the road feature. The species, especially, ground moles would be prevented from moving outside this area. If they move then, chances of being crashed by vehicles or exposed to predation on the road are high. This incident would also occur to the crawling insect, reptiles and amphibians. Fragmentation of habitats by the development activities will interfere with spatial connections of various habitats. Some of the areas act as "transit habitats" for some species. Disconnection of the habitat would therefore prevent further movement of the species in search of suitable environmental conditions. This phenomenon will potentially affect species diversity and population gene flow. Sounds (noises) generated by the operating equipments and vehicles is, however, envisaged to have minimal impact on mammals. Most of the species found here have been observed along highways grazing comfortably.

Anticipated impacts can be controlled by putting up mitigation measures that will act by preventing impact from occurring and controlling considerably the level of impacts. Avoidance of activities have been suggested where the construction is perceived to be a threat to priority species population or sensitive habitats. Alternative suggested mitigation measures are suitable for the project that runs for long term. These measures take care of ecological processes that their impacts are seen in the long run.

In order to maintain dispersal of animal species in the wider landscape, vegetation that provide connectivity should not be conserved. Movements crawling organisms across the landscape can be enhanced by creating underpasses on roads such as culverts at appropriate interval. This will ensure passage to the other side of the road and reduced road kill incidences. Introduction of speed limits will also control incidences of road kills of mammals and reptile species.

Effective implementation of proposed mitigation measures at different phases of the project will ensure any negative impact of the project is controlled to considerable level.

9 GAPS IN KNOWLEDGE AND UNCERTAINTIES ENCOUNTERED DURING THE STUDY

- The study of impact of wind turbines on biodiversity is new in the country. Interpretation of impact of the project development was challenging. In addition acquiring secondary data from local institution was challenging.
- The survey of threatened species in the IUCN redlist was very difficult. This was because the species are rare in distribution hence difficult to locate. Methodology that was used was stratified, random and free walk to improve on record of species. These however did not realize this particular group other than *Osyris lanceolata* that is nationally protected.
- Kipeto area is normally windy and cold in the morning. This condition does not favour most of insects and reptiles. This is the time they ought to be actively feeding. They would take cover in the bushes and on tree trunk to avoid extreme weather condition. This made it difficult to sight them in the morning.
- Study of movement of mammals, especially large species required study for a period of 18 months to capture how they move in different seasons. However, local knowledge was used to delineate movements

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APPENDIX I: Checklist of Plant Species in Kipeto and IUCN Red List Data

Species Name	IUCN Red list data (IUCN 2011)
Acacia drepanolobium	No entries found
Acacia brevispica	No entries found
Acacia gerrardii	No entries found
Acacia xanthophloea	No entries found
Acacia tortilis	No entries found
Acacia nilotica	No entries found
Glycine wightii	No entries found
Commiphora Africana	No entries found
Ficus sycomorus	No entries found
Aloe volkensii	No entries found
Aloe spp.	No entries found
Dovyalis abyssinica	No entries found
Dovyalis caffra	No entries found
Euphorbia tirucalli	No entries found
Euphorbia candelabrum	No entries found
Croton dichogamus	No entries found
Acalypha racemosa	No entries found
Euclea divinorum	No entries found
Tarchonanthus camphorates	No entries found
Psiadia panctulata	No entries found
Maytenus senegalensis	No entries found
Cordia ovalis	No entries found
Balanites aegyptiaca	No entries found
Cussonia holstii	No entries found
Acokanthera schimperi	No entries found
Carissa edulis	No entries found
Plumeria rubra	No entries found
Rhus natalensis	No entries found
Rhus vulgaris	No entries found
Lantana trifolia	No entries found
Vitex ???	No entries found
Grewia similis	No entries found
Grewia bicolor	No entries found

Species Name	IUCN Red list data (IUCN 2011)
Dombeya rotundifolia	No entries found
Datura stramonia	No entries found
Solanum anguivis	No entries found
Solanum nigrum	No entries found
Gardenia ternifolia	No entries found
Tarenna graveolens	No entries found
Scutia myrtina	No entries found
Digitaria milanjiana	No entries found
Cynodon dactylon	No entries found
Eragrostis tunuifolia	No entries found
Aristida adoensis	No entries found
Lippia javanica	No entries found
Ipomea obscura	No entries found
Boerhavia diffusa	No entries found
Pilicosepalus curviflorus	No entries found
Achyranthes aspera	No entries found
Plectranthus comosus	No entries found
Leonotis nepetifolia	No entries found
Ocimum suave	No entries found
Persicaria pulchrum	No entries found
Commelina Africana	No entries found
Cyphostema orondo	No entries found
Kalanchoe sp.	No entries found
Abutilon mauritiana	No entries found
Justicia exigua	No entries found
Cyperus alternifolius	No entries found
Cyperus sp.	No entries found
Olea Africana	No entries found
Osyris lanceolata	No entries found
Leucas glabrata	No entries found
Asparagus Africana	No entries found
Phyllanthus amarus	No entries found

APPENDIX II: Checklist of Insect Pollinators in Kipeto and IUCN Red List Data

	Species	Habitat Found	Seasons		IUCN Red list data (IUCN 2011)
			Wet	Dry	
1	*Papilio demodocus*	Bush and woodland areas	√	×	No entries found
2	*Zizula hylax*	Grassland and grass areas in bushland/woodland	√	√	No entries found
3	*Azanus jesous*	Grassland and grass areas in bushland/woodland	√	×	No entries found
4	*Euchrysops malathana*	Grassland and grass areas in bushland/woodland	√	×	No entries found
5	*Eurema floricola*	Grassland and grass areas in bushland/woodland	√	×	No entries found
6	*Eurema regularis*	Grassland and grass areas in bushland/woodland	√	×	No entries found
7	*Colotis aurigineus*	Bush and woodland areas	√	√	No entries found
8	*Colotis danae*	Bush and woodland areas	√	×	No entries found
9	*Colotis antevippe*	Bush and woodland areas	√	√	No entries found
10	*Colotis evagore*	Bush and woodland areas	√	√	No entries found
11	*Belenois aurota*	Bush and woodland areas	√	×	No entries found
12	*Belenois creona*	Bush and woodland areas	√	×	No entries found
13	*Belenois crawshayi*	Bush and woodland areas	√	×	No entries found
14	*Belenois thysa*	bushland/woodland and grassland near bushland/woodland	√	×	No entries found
15	*Dixeia sp.*	Bush and woodland areas (Riparian)			No entries found
16	*Dixeia pigea*	Bush and woodland areas (Riparian)	√	√	No entries found
17	*Mylothris agathina*	bushland/woodland and grassland near bushland/woodland	√	×	No entries found
18	*Neocoenyra gregorii*	bushland/woodland and grassland near bushland/woodland	√	×	No entries found
19	*Charaxes zoolona*	Bush and woodland areas (Riparian)	√	×	No entries found
20	*Junonia oenone*	Bush and woodland areas	√	×	Least Concern
21	*Junonia hieta*	Bush and woodland areas	√	×	No entries found
22	*Précis archesia*	Bush and woodland areas	√	×	No entries found
23	*Vanessa cardui*	Bush and woodland areas	√	×	No entries found
24	*Acraea spp.*	Bush and woodland areas	√	×	No entries found

	Species	Habitat Found	Seasons		IUCN Red list data (IUCN 2011)
			Wet	Dry	
25	*Eretis Umbra*	Bush and woodland areas	√	×	No entries found