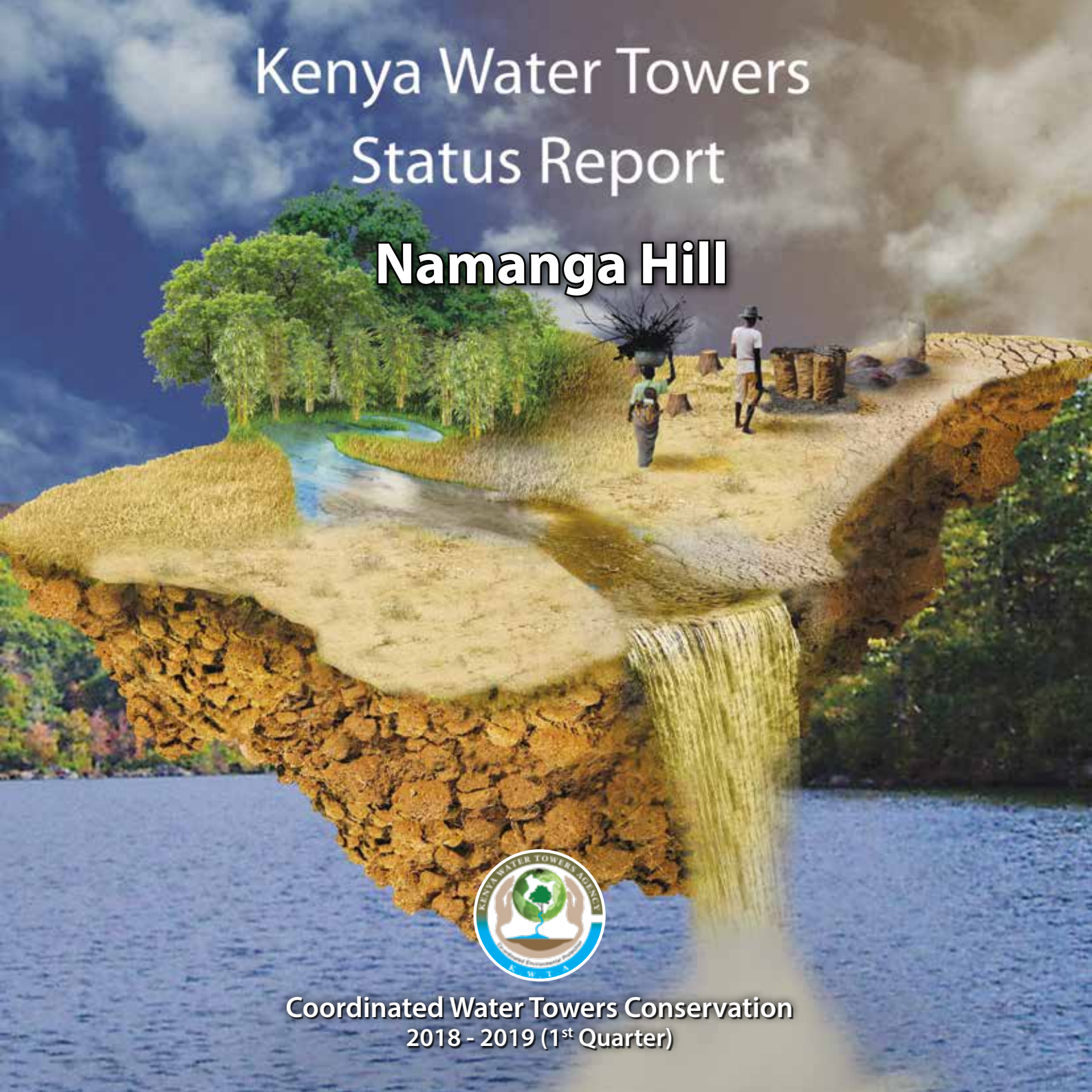
Kenya Water Towers Status Report

Namanga Hill



Coordinated Water Towers Conservation

2018 - 2019 (1st Quarter)

Kenya Water Towers Status Report

for
Namanga Hill

Coordinated Water Towers Conservation
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Kenya Water Towers Agency

Ragati Road, NHIF Building, 15th Floor

P.O. Box 42903-00100

Tel: 020 271 1437

Email:info@watertowers.go.ke

www.watertowers.go.ke

Statement by the Cabinet Secretary

Conservation of Water Towers is crucial in achieving Sustainable Development Goals (SDGs), National Development Agenda and supporting GDP growth. Chapter Five of the Constitution provides the need to ensure sustainable exploitation, utilization, management and conservation of the environment and natural resources. However, Water Towers are facing serious threats that require urgent intervention measures.

Namanga Hill Water Tower is an important biodiversity area with 665 plant species, 42 species of mushrooms, 38 reptiles, 140 birds' species, and 41 animal species. The Water Tower is also an important water source with 17 springs and several rivers which provide water for livestock, wildlife and domestic use and also a major source of water for Namanga town. However, charcoal production, unclear forest boundary, poaching of indigenous trees, soil erosion, overgrazing among others threats has led to drying of springs, resource use conflicts and biodiversity decline.

Increased protection and surveillance of the water tower efforts has seen a gradual recovery of forest cover by 2,500 ha (40%) in the last 3 decades. The Ministry has been working with various stakeholders to rehabilitate degraded areas in Namanga Hill Water Tower. Efforts which include moratorium on logging, promotion of tree planting in schools such as Kiluani Boys Secondary in Namanga are all aimed at increasing tree cover to 10% by 2022.

I therefore call upon state and non-state actors as well as development partners to come on board and support restoration efforts in Namanga Hill Water Tower. As indicated in the implementation plan, 262 million will be required to restore the Water Tower and therefore this requires concerted efforts.

Lastly, I want to thank H.E President Uhuru Kenyatta for supporting conservation efforts in Water Tower.

Mr. Keriako Tobiko, CBS, SC
Cabinet Secretary
MINISTRY OF ENVIRONMENT AND FORESTRY

Remarks from the Principal Secretary

Water Towers support all aspects of our lives. It is the most important source of water to majority of the population and supports key sectors which include agricultural, energy, manufacturing and tourism. These fragile ecosystems continue to recharge our rivers and aquifers as well as maintaining micro-climatic conditions in the hinterland.

Despite their importance, Water Towers face a myriad threats and challenges which include encroachment, population pressure, forest fires, charcoal production, unsustainable land management practices, invasive species, inadequate infrastructural facilities as well as poor enforcement of laws and regulations. As a result, Kenya lost 311,000 forestlands between 1990 – 2015 due to conversion to settlement, crop farming and infrastructural development. Some of the key impacts of these have been drying of rivers and decline in water supply as a result of drought that has been experienced in the Country in the recent past.

The Government, through the Ministry of Environment and Forestry, has made tremendous efforts in reclaiming encroached Water Towers and putting in place mechanism such as fencing to control further encroachment. The tree planting campaign spearheaded by the Ministry has brought on board State Agencies, County Governments, private sector, development partners and communities living around the Water Towers. In the financial year 2019/2020, the Government allocated KES 1 Billion towards achieving and maintaining 10% tree cover by 2022 campaign. I therefore call upon Kenyans including the private sector and other non-state actors, other Government

Agencies and international partners to render their support towards conservation of our Water Towers.

Dr. Chris Kiptoo, CBS
Principal Secretary
MINISTRY OF ENVIRONMENT AND FORESTRY

Foreword

Kenya Water Towers Agency has continued to play a leading role in supporting Governments' effort in restoring the country's Water Towers. The Agency develops Water Towers Status reports to provide detailed information crucial for making informed decisions and policy recommendations towards sustainable management and conservation of Water Towers. This ensures water towers resources are available to support achievement of Government's key National agendas especially the Big Four on; Affordable Housing, Industrialization, Food security and Universal health Care.

In order to sustainably conserve Namanga Water Tower, there is need for continuous community sensitization and regular patrol and surveillance to curb illegal activities. In addition, it is necessary to promote community livelihoods options as a way of reducing their overreliance on Water Tower resources. KWTA has initiated a biogas plant in one of the schools adjacent to the Water Tower as an alternative source of energy. With support from the Government and development partners we plan upscale these initiatives and implement other proposed interventions highlighted in the report.

I acknowledge support from the Government, the parent Ministry and stakeholders' contribution towards conservation of the Water Towers. I would also like to appreciate KWTA Board of Directors and the management for ensuring timely production of this report.

Dr Julius M Malombe
Board Chairman
KENYA WATER TOWER AGENCY

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Prof. Julius G Tanui, PhD, EBS
Ag CEO, Secretary to the Board

Preface

Namanga Hill Water Tower Tower is located in Kajiado County, at the Kenya-Tanzania border. The Water Tower is a catchment for 17 permanent springs, three permanent and two seasonal rivers. It is an important biodiversity hotspot with a total of 2,208 plant and animal species. It also provides ecosystem goods and services that are key in sustenance of the livelihoods of the local communities. For instance, it is a source of water for people living within and beyond the Water Tower and also used as a grazing ground for livestock during dry season.

Despite the importance and benefits derived from this Water Tower, it faces various threats including soil erosion, invasive species such as Ipomea, unclear forest boundary that has led to encroachment in some sections of the forest, charcoal production and overgrazing. Continued degradation has negatively impacted the livelihoods of the local community, the economy and biodiversity. In this regard, there is need for concerted efforts from both state and non-state stakeholders as well as the community to participate in its restoration. We are therefore calling upon all stakeholders to partner with KWTA in conserving this important ecosystem.

I take this opportunity to thank the KWTA Board, KWTA Senior Management and the staff for their contribution in the development of this report. I also recognize the Directorate of Ecosystem Research, Planning and Audit in coordinating the research activities that has led to production of this report. Lastly, I extend my appreciation to all stakeholders who contributed towards development of this report.

Prof. Julius G Tanui, PhD, MBS
Ag. Chief Executive Officer
KENYA WATER TOWERS AGENCY

Executive Summary

The status report gives a detailed assessment of Namanga Water Tower in Kajiado County. The objective of the status report is to provide information to advice on policy making and guide restoration activities in the Water Tower. The report provides the status of land cover and land use changes in the Water Tower between 1990 – 2018. It also highlights biodiversity distribution, abundance and biodiversity hotspots, critical catchment areas, Socio-economic status of the people living around the water tower and a profile of stakeholders involved in conservation activities within the Water Tower. The report further enumerates the threats and challenges facing the Water Tower while stating the intervention measures and an implementation plan for restoring the Water Tower.

Namanga hills Water Tower is a cross-boundary resource in Kenya and Tanzania border. It covers 41,258 ha and comprises of 11,903 ha of gazetted forest and 29,355 ha of 5-kilometer buffer zone. There are three permanent and two seasonal rivers which join Namanga River and flows to Amboseli National Park. The Water Tower has seventeen permanent springs. The rivers and springs are important sources of water to more than 20,000 people living in and beyond the Water Tower and is used mainly for domestic and irrigation purposes. The Water Tower is also an important biodiversity area with a total of 2,208 plant and animal species. These include 665 vascular plants, 42 mushrooms, 41 mammals, 140 birds, 1270 invertebrates, 38 reptiles and 12 amphibians. The study identified areas around Maili Tisa town, Namanga and border of Tanzania and Kenya as key biodiversity hotspots. The level of degradation in these areas is high characterized by deep gullies and sparse vegetation cover. As a result of increased surveillance along the Kenya-Namanga border, forest cover increased gradually by 37.9 % while grassland which is important for the pastoral communities declined by 10.5% indicate the period. Cropland was rare in 1990, but increased by 46.8% in 2018 as a result of adoption of agro-pastoralism by the local community.

The magnitude of the threats on the Water Tower is severe resulting from increasing human population. For instance, overgrazing has led to soil erosion and deep gullies on the foot hill zone. There is also rapid spread of invasive species such as Ipomea species, Khaki weed and Solanum which have colonized grazing areas on the eastern section of the Water Tower. Despite increased

surveillance, there are still cases of illegal charcoal production driven by high demand in the surrounding towns as well neighboring country, Tanzania. Proximity of Namanga Water Tower to Amboseli National Park has led to increased human-wildlife conflicts due to interference with wildlife corridors. The impact has been loss of life, property destruction and loss of wildlife. This has resulted to incidences of encroachment for farming and settlement on the Eastern side of the hill. The study also noted low level of community awareness on the need to conserve the Water Towers. In order to restore the ecosystem integrity of Namanga hill Water Tower, there is an urgent need to address these threats which have had a great impact on ecosystem services provided by the Water Tower. An estimated budget of Ksh. 262 Million is proposed to undertake the following interventions measures in order to conserve the Water Tower;

1. Enhance sensitization and community awareness on Water Tower conservation
2. Capacity building on nature-based strategies such as bee keeping and promotion of agro-forestry around the Water Tower to alleviate pressure on the Water Towers resources.
3. Rehabilitation of degraded areas and protection of biodiveristy hotspot as well as critical catchment areas through sustainable land management practices such as building of gabions and planting indigenous tree species.
4. Rehabilitating the springs and other critical catchment areas through bamboo establishment.
5. Promotion of alternative sources of energy such as solar, briquettes, biogas and energy efficient jikos to reduce over-reliance wood fuel
6. Promotion of sustainable livestock management programs such as improved livestock breeds and hay production.
7. Control of invasive species in the buffer zone and promotion of hay production for both domestic and commercial use.
8. Enhance monitoring and surveillance of the Water Tower to control illegal activities such as charcoal burning and poaching of indigenous trees.
9. Development and implementation of an Ecosystem Conservation and monitoring plan for enhanced sustainable management of the Water Tower

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Abbreviations and Acronyms

a.s.l	Above Sea Level
CFA	Community Forest association
CIDP	County Integrated Development Plan
DN	Digital Numbers
GDP	Gross Domestic Product
ha	Hectares
IPCC	Intergovernmental Panel on Climate Change
ITCZ	Inter-tropical Convergence Zone
IUCN	International Union for the Conservation of Nature
KFS	Kenya Forest Service
KIFCON	Kenya Indigenous Forest Conservation
km	Kilometre
KWS	Kenya Wildlife Service
KWTA	Kenya Water Towers Agency
LCLU	Land Cover Land Use
m	Metre
m^3/s	Cubic Metre per Second
ML	Maximum Likelihood
NRC	Non-Residential Cultivation
RF	Random Forest

UNESCO	United Nations Educational, Scientific and Cultural Organization
USGS	United States Geological Survey
WRA	Water Resources Authority

Definition of Terms

Water Tower
An elevated geographical area comprising mountains, hills, and plateaus where the topography, geology, soils and vegetation support reception, retention, infiltration, and percolation of precipitation and storage as ground water, that is eventually released through springs, streams, rivers, swamps, lakes, and oceans to sustain connected biodiverse ecosystems and is harnessed for use

Watershed
An area or ridge of land that separates waters flowing to different rivers, basins or seas

Drainage Basin
It is an area of land where all water that falls on that land flows into one river

Drainage system
The pattern formed by streams, rivers, and lakes in a particular drainage basin

Landcover
Is the physical material on the surface of the earth

Land use
Refers to human activities/foot prints on the surface of the earth

Land Use and Land Cover Changes
Changes that occur in land use and land cover over time based on satellite imagery analysis

Land Use and Land Cover Trends
Transitional changes in land use and land cover over a period of time

Buffer
An area of specified distance around a forest (in this case 5 km from the edge of the forest)

Geographical Information Systems (GIS)
Is a system designed to capture, store, manipulate, analyze, manage, and present geographical data

Remote Sensing
Process of obtaining data without being in physical contact with the object, as applied mainly by space satellite in acquiring satellite imagery of the earth from space

Global Positioning System (GPS)
Is a network of orbiting satellites that send precise details of their position in space back to earth and are used to provide position on the earth surface

Ecosystem services
Are the many and varied benefits that humans freely gain from the natural environment and from properly-functioning ecosystems

Ecosystem values
Measures the importance of ecosystem services to people

Total Economic Valuation
It is a tool for determining the benefits of an environmental system to people by assigning monetary value to all ecosystem goods and services

River flow
Volume of water flowing on a stream at a given time

Biodiversity
The variety of plant and animal life in the world or in a particular habitat, which is usually considered to be important and desirable

Endemic species
These are plants and animals that exist only in one geographic region.

1.0 Introduction

Water towers are multi-functional and provide significant ecosystem goods and services that are important for the livelihoods and biodiversity of the surrounding communities and the wider region in which they occur. The ecosystem goods from the water towers include provision of firewood, honey, pasture, herbs and medicinal plants, and water for domestic and livestock production. The environmental services include provision of carbon sinks for climate change mitigation, water purification and storage for recharge of ground water and rivers, and are reservoirs of biodiversity for flora and fauna.

"Thousands Lived without Love, but not without water. So SAVE WATER"
Adopted from best slogans for save water awareness and scarcity

Water towers vary in size, shape, drainage patterns and features. In the early 2000, only five water towers were legally recognized in Kenya namely; the Mau Forest complex, Mt. Kenya, the Aberdares, the Cherangany hills and Mt Elgon (GOK, 2006). Thereafter, the Kenya Water Master Plan (GOK, 2012) identified 13 other significant water towers that provide water to the local populations, particularly in hilly and mountaineous areas in dry lands (Figure 1.1). These smaller Water towers have been given better recognition by the formation of the Kenya Water Towers Agency (KWTA) established in 2012 to coordinate and oversee the protection, rehabilitation, conservation and sustainable management of water towers. As at December 2018, KWTA had identified 69 additional ecosystems that have been proposed by stakeholders and are yet to be subjected under the criteria for identification of water towers (Table 1.1).

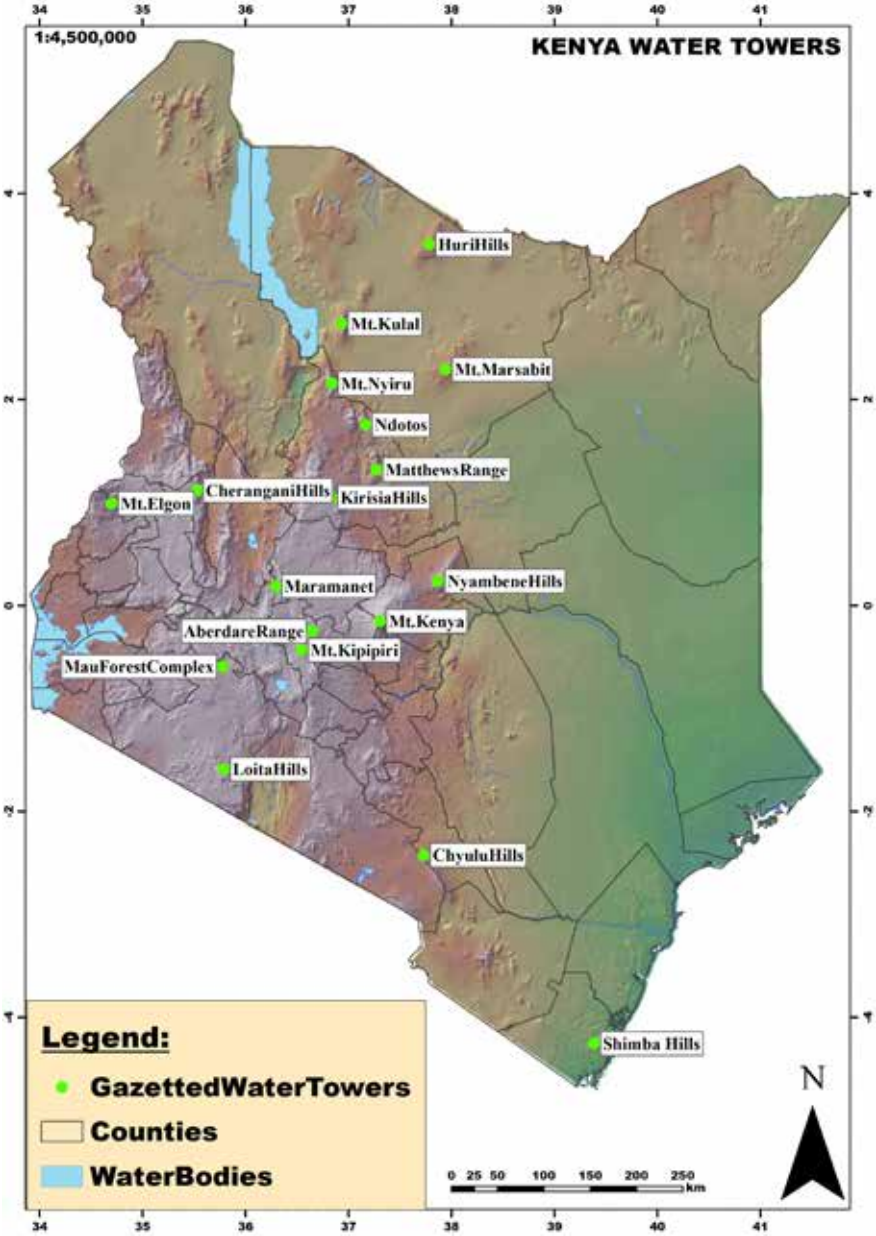


Figure 1.1: Gazetted Water Towers in Kenya

Table 1.1: Proposed Water Towers by the various stakeholders

Kajiado County Ngong hills Namanga hill Emali hills Maparasha hills	**Nyamira County** Manga hills Sironga wetland	**Machakos County** Machakos hills Kibauni hills Kanzalu hills Matetani hills Iveti hills Oldonyo Sabuk	**Meru** Imenti hills Ngaya hills	**Embu** Kirimiri hills Kiang'ombe hills
Homa Bay Gwassi hills	**Nyeri County** Karima hills Tumutumu hills Kiamacheru hills Nyara hills Nyeri hills	**Kilifi County** Mwangea hills	**Baringo County** Tugen hills	**Kisii** Nyangweta hills Sameta hills Taracha hills Nyacheki hills
Elgeyo Marakwet Elgeyo hills		**Makueni County** Makuli hills Mbooni hills Nthangu hills Nzaui hills Makongo hills Kilungu hills Mbui Nzau hills Yekanga hills	**Nakuru County** Subukia escarpment	**Nandi County** Kibirong swamp Kingwal swamp
Turkana Loima hills	**Taita-Taveta** Taita hills Kasigau hills		**Narok** Mt. Suswa	**Lamu County** Lake Kenyatta

Migori Maeta hills Magaimuya hills Taragwiti hills	**Nyandarua County** Maungu hills	**Kitui County** Mutito hills Endau hills Kavonge/ Museve hills Mutuluni hills Mumoni/ Ngaikuyu hills Kyawea hills Mutha hills Nuu hills	**Kiambu** Kikuyu escarpment	
Laikipia Mukogodo hill	**Kajiado County** Nguruman Escarpment		**Uasin Gishu** Leseru Swamp	**West Pokot.** Chebuko/ kamalegon Karasuk hills

Protection and conservation of these important ecosystems continues to face a number of challenges. Rapid population growth whose spiral effects include increased land fragmentation, encroachment and over exploitation of natural resources within the water towers ecosystems. These have resulted to adverse environmental impacts such as drying up of rivers, dams and springs; loss of biodiversity and changes in micro-climatic conditions (Figure 1.2).

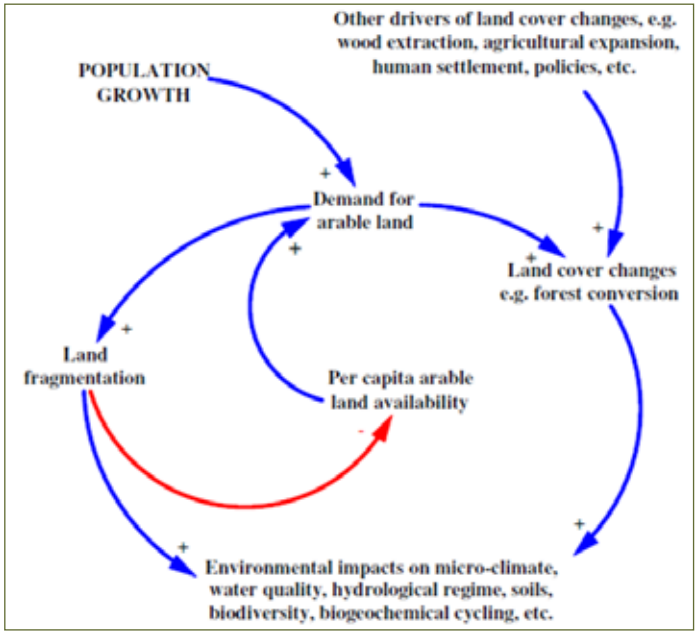


Figure 1.2: Causal Loop Diagram Illustrating Threats Facing the Water Tower. *Note: The positive (+) sign denotes an increasing effect while the negative (-) sign denotes a decreasing effect)*

1.1 Water Tower Status Quarterly Report

KWTA envisages to be a global leader on sustainable management of water towers in the country. It intends to realize the vision through data based sustainable management of the water towers and the surrounding ecosystem as provided in the Agency's legal notice and the inaugural strategic plan 2016-2020. It intends to achieve this through following strategic areas:

i. To Coordinate Water Towers Ecosystem Health and Resilience

ii. To Coordinate and Oversee Securing of Catchment Lands, Wetlands, and Critical Biodiversity Hotspots Within the Water Towers Ecosystems

iii. To Acquire Appropriate Infrastructure to Support Sustainable Management of Water Towers

iv. To Promote Sustainable Livelihood Support Programmes Within the Water Towers

v. To Establish Strategic Partnerships and Linkages for Sustainable Management of Water Towers

vi. To Undertake Institutional Strengthening for Effective Service Delivery

To realize the objective on the strategic area on coordination of water tower ecosystem health and resilience, provision of current information on the status of Kenya's water towers is required. The information should provide indications on the temporal and spatial changes in the water ecosystem health and resilience while identifying the level of degradation and the causal factors. Further, it will assist government and non-government stakeholders to identify priority measures for safeguarding the health and resilience of the ecosystems. Finally, the water tower status information is crucial for formulation of ecosystem management plans that will provide a road map and facilitate coordinaton of stakeholders for the protection and conservation of water towers.

"Life depends on water, the reservoir depends on you."

From best slogans for save water awareness and scarcity

KWTA undertakes assessment of the water tower ecosystems and publishes the findings in quarterly status reports disseminated to Cabinet, Parliament, County Governments and other key stakeholders for information and action.

The report focuses on Namanga Hills Water Tower. The overall focus of the report is to provide key information on the status of the target water towers for informed decision making and sustainable management by Government and all other stakeholders. The information collected will also inform the alternative livelihood options to be implemented to reduce pressure exerted on the water towers ecosystem.

Overview of the report:

i. Methodology of the study, location, size and bio-physical attributes;

ii. Land use and land cover changes between 1990 and 2018;

iii. Hydrological attributes for the critical water catchment areas;

iv. Socio-economic status and livelihoods of the surrounding communities;

v. Critical water catchment and biodiversity hotspots for conservation and rehabilitation;

vi. Threats on conservation and protection of the water towers;

vii. Stakeholders and their role in the conservation and rehabilitation of the water towers;

viii. Conservation and management actions;

ix. Recommend Water towers conservation strategies towards conservation and rehabilitation of the water towers.

1.2 Methodology

1.2.1 Socio-economic Data Collection

Socio-economic data was collected to understand interaction between the local communities and the Water Tower. The data collected would inform alternative livelihood programs to be implemented to reduce local community's dependence on the Water Tower resources.

The data was collected through administration of questionnaires. The respondents were stakeholders with the mandate of managing water towers resources as well as those living

within the water tower (5km buffer zone). Focused group discussions were also held at the location level to collect information from communities living around the water tower.

1.2.2 Biodiversity Hotspot Identification and Mapping

The analysis commenced with review of literature including the Global Biodiversity Information Facility (GBIF) that were used to get data for all taxa (Plants, mushroom, amphibians and reptiles, invertebrates, birds and mammals). Desktop analysis was used to generate preliminary classification of hotspots as hot, moderately hot or less hot in terms of biodiversity richness index.

(i) Plants

Sampling was done along linear transects in various sample plots determined as hotspot areas. Specimen identification was done at the East African Herbarium for those that were difficult to identify in the field.

(ii) Macro fungi (Mushrooms)

Macro fungi collection and identification were done within the hotspot areas. Features such as habitat, color of fresh macro fungi, nature of substrate and associated plant species were recorded and identified at the National Museums of Kenya laboratory.

(iii) Reptiles and amphibians

Searches were carried out within each sampling point in all possible reptile and amphibian micro-habitats such as; tree barks, under stones, decomposing logs, tree stumps, holes, shrubs, bushes and digging within loose soils. All the different species and number of reptiles and amphibians found were recorded. Additionally, the local community provided information pertaining the reptiles and amphibians. Published taxonomic keys (Spawls et al., 2018; Channing and Howell, 2006) and taxonomy for amphibians were used for identification. Where necessary, specimens were euthanized and fixed in 10% formalin. All the materials collected were deposited at the herpetology collection of the National Museums of Kenya (NMK), Nairobi.

(iv) Birds

a) Qualitative Methods

Opportunistic bird searching was carried out in forest and Acacia woodland habitats. Bird species seen or heard were recorded, the habitat in which they occurred and the duration spent birding.

b) Quantitative Methods

Timed Species Counts (TSCs): Timed Species Counts were performed over a fixed time period of 60 min and over fixed routes recording all birds seen ("s") or heard ("h"). The TSCs were carried right after sunrise for four hours (6am – 11 am).

(v) Mammals

Mammals were recorded by walking along transects searching for individuals as well as their signs (Hoffmann et al. 2010). Search for animals were made from morning to evening along these transects (JOFCA 2002). Any animal sighted or flushed from the bush or trees, scats or burrows which were identified to species were mapped using GPS. Local community guides were interviewed to confirm the presence or absence of selected large mammal species.

(vi) Invertebrates

Transects were established within the hotspot areas with each measuring 1km with three working stations, at 0m, 50m and 1000m. The following techniques were employed:

- Timed Direct Search
- Pan traps
- Pitfall traps
- Baited butterfly traps

Biodiversity Hotspot Analysis

Generation of biodiversity hotspot was determined by the following main factors:

- Species richness and species distribution
- Environmental threats
- Frequency of micro-habitats
- Ecological functions

Field validation was conducted to confirm hotspot index generated during desktop work using variables listed for assessment. The

process and datasets used in analyzing hotspots areas are summarized in Figure 1.3 below.

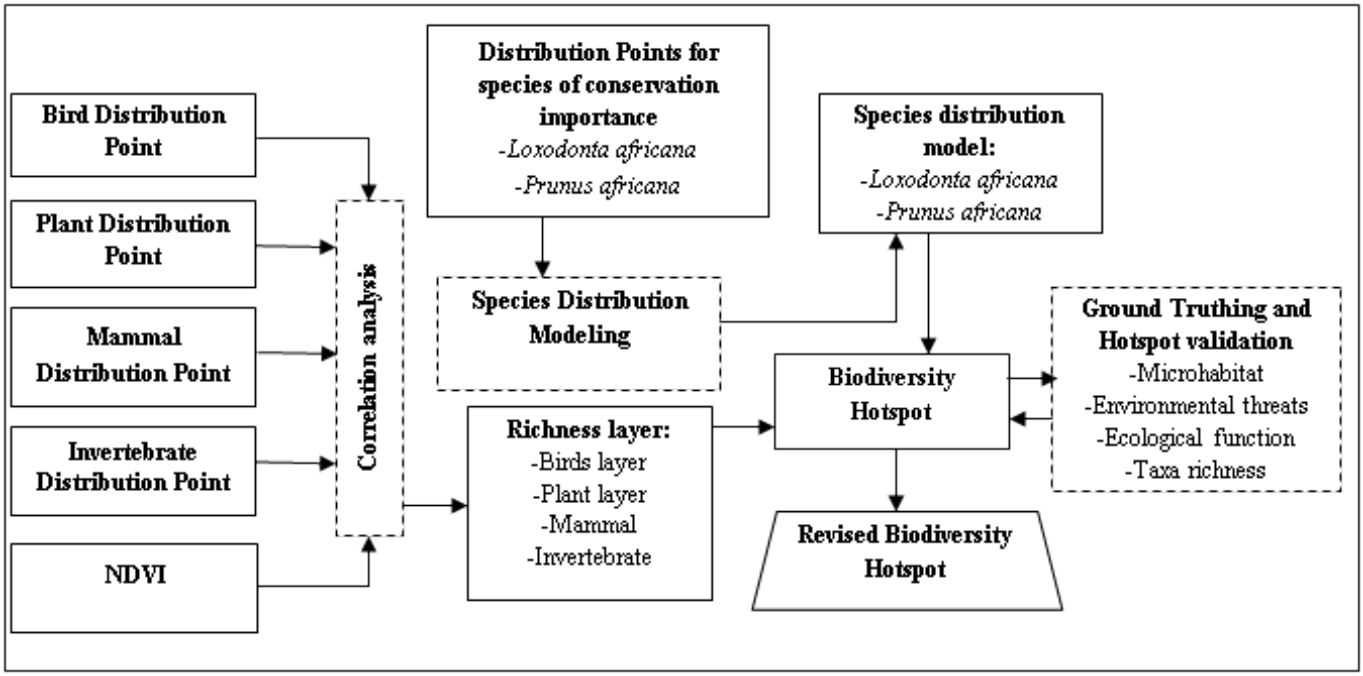


Figure 1.3: Datasets and process of mapping Biodiversity hotspot areas in the Water Towers

1.2.3 Land Cover and Land Use Assesment

Multiple analytical methods were used to study and interpret Land Cover and Land Use (LCLU) changes and explore the drivers and socio-economic impacts over time and space. Geographic Information System (GIS) and Remote Sensing (RS) techniques were used to carry out LCLU assessment (Figure 1.3). Classified LCLU from the satellite imagery using Random forest classifier were validated using ground truthing points collected during fieldwork. The LCLU changes in the water towers were determined by undertaking image differencing of 1990 image with the latest classified image using ERDAS Imagine software and statistics tabulated as conversion matrix using Microsoft Excel.

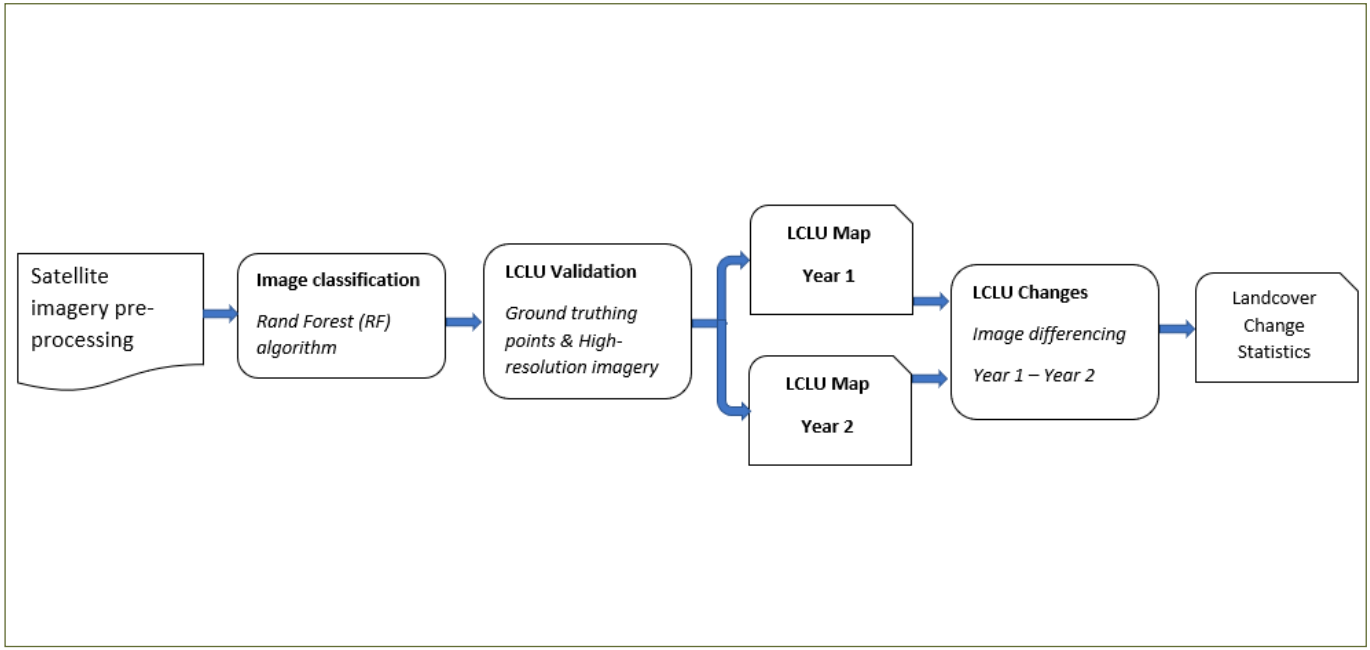


Figure 1.4: Process of mapping land cover and land use in the Water Tower

1.2.4 Assesment of Degradation Status

In order to determine degradation levels, LCLU maps were overlaid with slope data using weighted overlay in ArcGIS. The weight of influence was set to range between 1-3 where by '1' has little or no influence on degradation and '3' has the highest probability of being degraded. The overall weights of influence for the two datasets were set at 60% for the land cover and 40% for the slope. This means an area with less vegetation cover and steep slope has high likelihood of being degraded and the same area provides opportunity for rehabilitation. The degradation map was validated using ground truthing data which included GPS points of gullies and areas where trees have been cleared.

"We spend billions of dollars looking for life on other planets and spend trillions killing this one" *Adopted from 40 clever environmental slogans, posters and quotes*

Namanga Hill Water Tower

Key Attributes

- Borders Namanga town and the Kenya-Tanzania border covering 41,258 ha
- Arid and semi-arid climate with an average temperature of 20.80C and annual rainfall in the range of 300-800 mm
- Plays a key role in the hydrology of Namanga town and is associated with three permanent and two seasonal rivers in addition to 17 permanent springs
- An important habitat to millions of animal and plant species due to minimum human disturbance and thus a cradle of biodiversity.
- Forestland increased gradually by 38% from 6,832 ha in 1990 to 9,422 ha in 2017 in the buffer zone while grassland which is important for the local pastoralist communities declined by 11% from 34,417 ha in 1990 to 30,793 ha in 2017 due to increased grazing pressure.

Key Threats and Challenges

- Large herds of livestock kept by the local maasai resulting in overstocking
- Frequent and prolonged droughts have aggravated due to the negative impacts of climate change
- Unclear forest boundary due to widely spaced and lost beacons
- Encroachment by invasive species
- Charcoal burning
- Low level of awareness
- Human-wildlife conflict

Proposed Interventions

- Installation of more beacons along the boundary
- Capacity building of CBO's
- Community awareness creation and sensitization
- Improving infrastructure and resource facilitation
- Promote alternative sources of livelihood
- Gully rehabilitation and restoration

Olchorro Onyokie river

2.0 Namanga Hill Water Tower

Namanga Hill Water Tower is also known as Ol Donyo Orok covering 41,258 ha including gazetted forest (11,903 ha) and a buffer zone (29,355 ha). The Water Tower borders Namanga town and the Kenya-Tanzania border in Namanga Sub-County of Kajiado County (Figure 2.1). Namanga Hill rises above the extensive plains of Amboseli basin to a height of 2,760m a.s.l. Namanga forest was gazetted through a legal notice of August 1979 as a natural forest reserve and placed under the direct management of the then Forest Department (currently Kenya Forest Service- KFS).

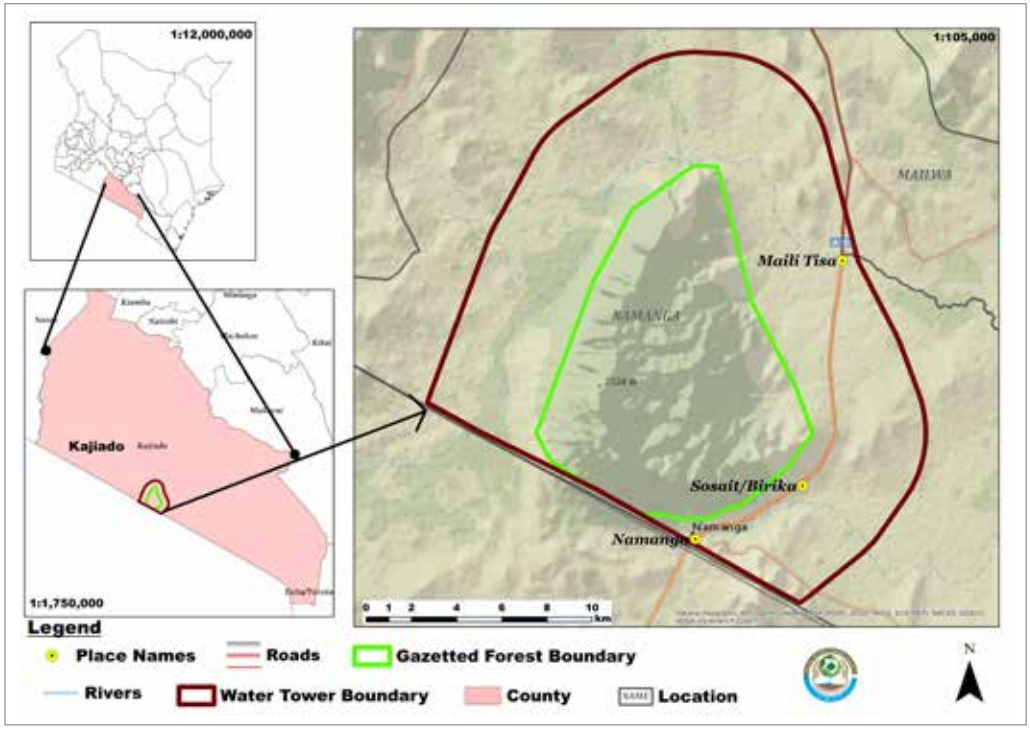


Figure 2.1: Location of Namanga Hill Water Tower

" Water is the most critical resource issue of our lifetime and our children's lifetime. The health of our waters is the principal measure of how we live on the land."

From best slogans for save water awareness and scarcity

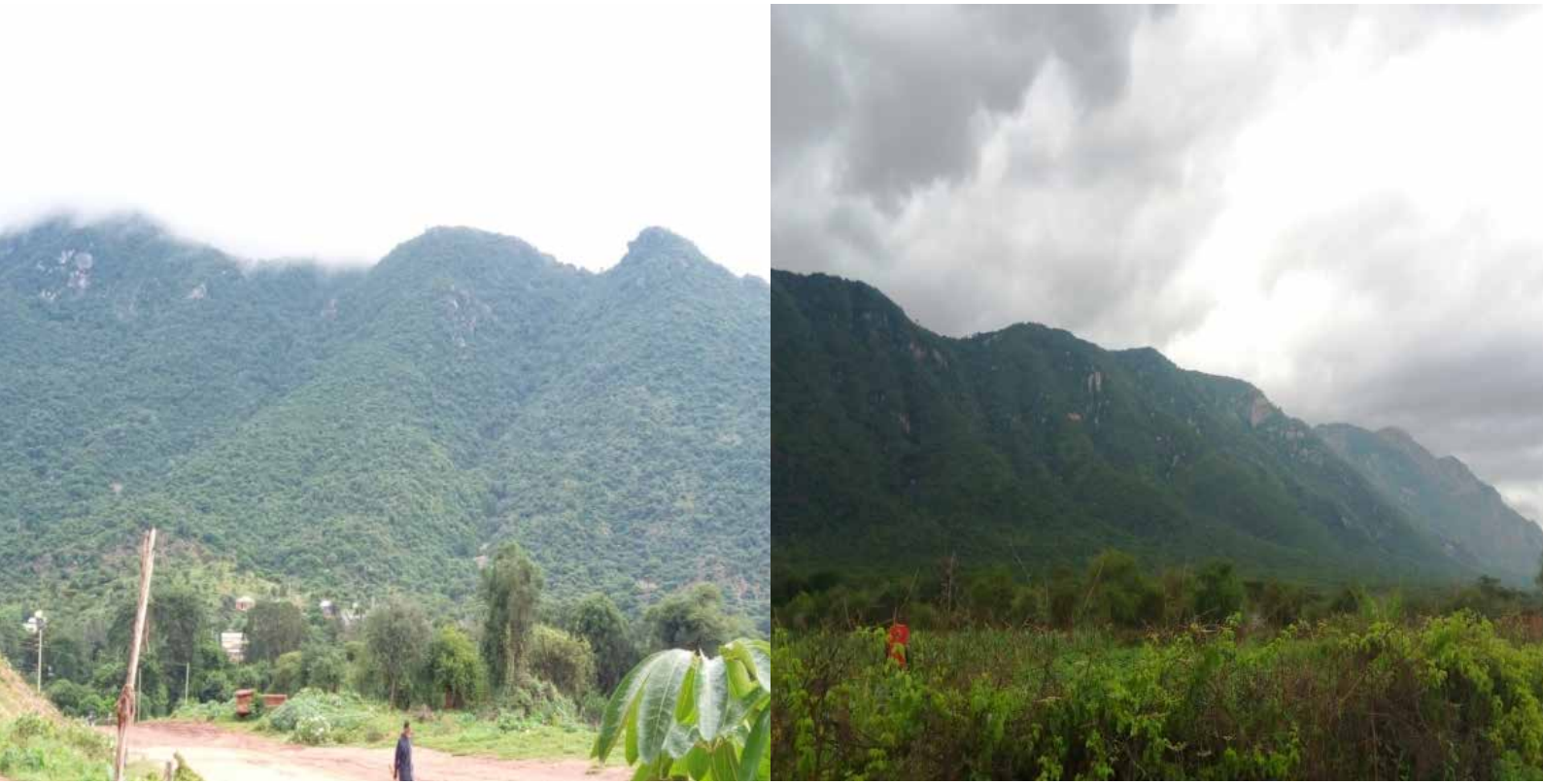


Plate 2.1: View of A Section of Namanga Hill from Namanga Town

2.1 Climate

Namanga Hill Water Tower lies in the semi arid lands of Kenya categorised as Agro Ecological Zone V. The average temperature is 21^{0}C with a maximum of about 23^{0}C in March and a minimum of 18^{0}C in July. The annual rainfall ranges between 300-800 mm with a bimodal distribution pattern, whereby short rains occur between October-December and long rains in March-May (Figure 2.2).

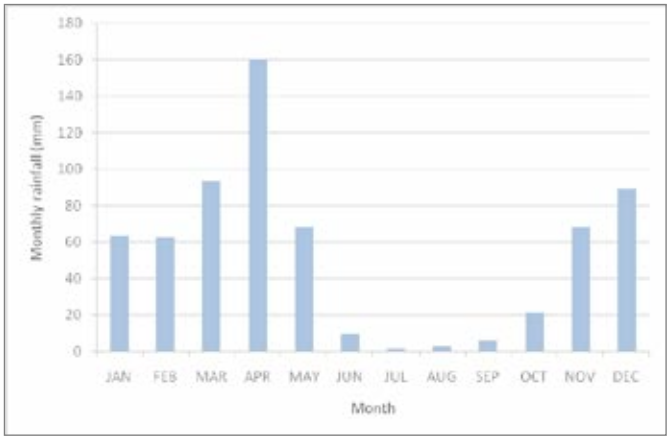


Figure 2.2: Monthly Rainfall Distribution in Namanga

"Waste water today – Live in desert tomorrow"
Adopted from 200 slogans on saving water

Namanga River

2.2 Hydrology

The Water Tower plays a key role in the provision of water in Namanga town and the bordering towns in Tanzania (Table 2.1; Figure 2.3). The water tower is a source of three permanent rivers (Namanga, Oloormotonyik and Olchorro Onyoike) and two seasonal rivers (Lesongoyo and Lendapidapoi). River Lesongoyo originates from Tanzania flowing through the water tower and Amboseli National Park while Oloormotonyik originates from Oloormotonyik spring and flows to Tanzania. Lendapidapoi river gets its water from Orgirra spring and flows to Oyarata area. These rivers vary in their flows with higher intensities during the wet seasons in comparison to dry seasons.

The Water Tower has a total of 17 springs; all permanent and located within the gazetted forest (Table 2.1). However, the water volume reduces during the dry period.

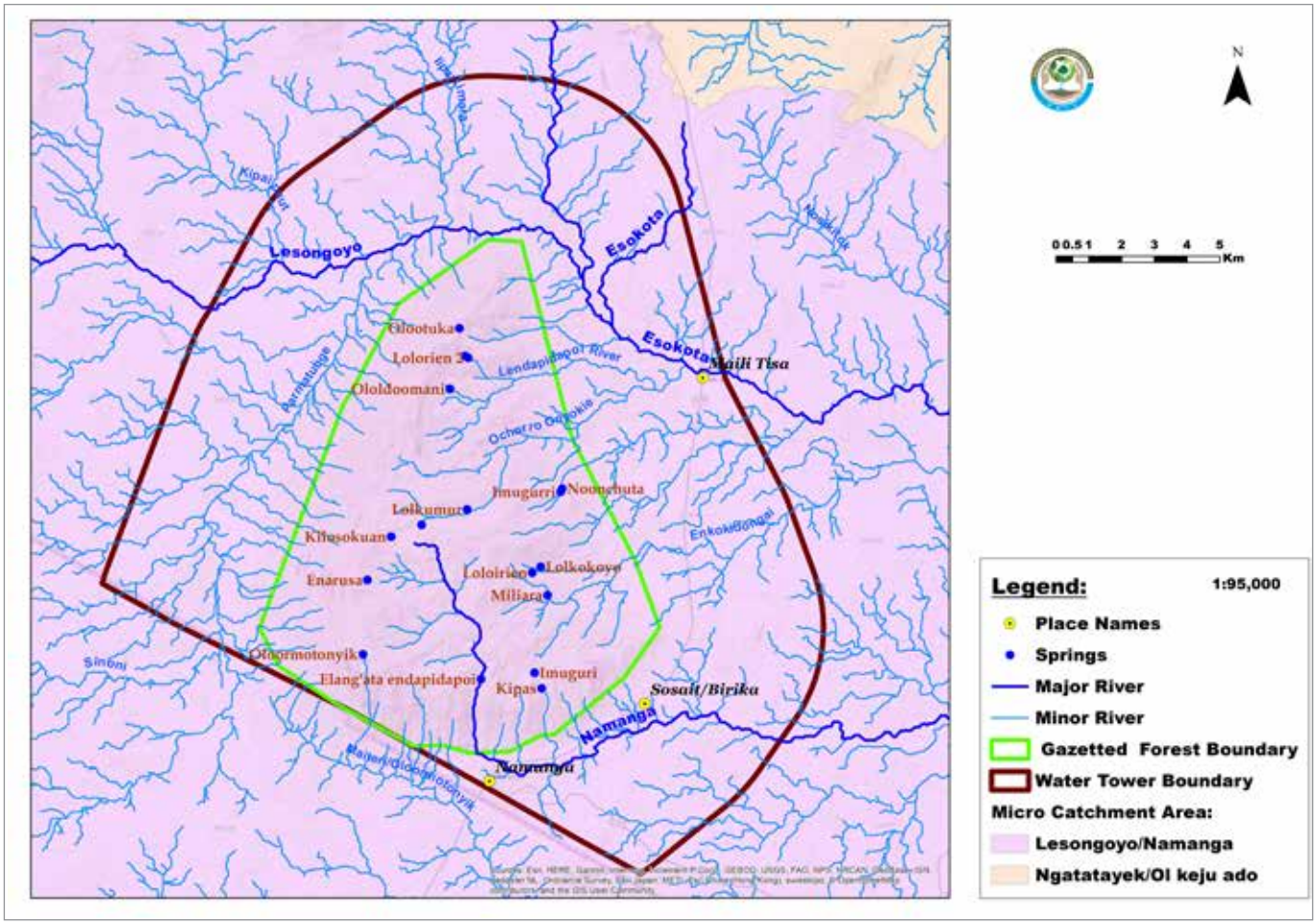


Figure 2.3: Spring and River Network in Namanga Hills Water Tower

Table 2.1: Springs in Namanga Hill Water Tower

No	Name	Location	Seasonality
1.	Ololdoomani	Ol Donyo Orok	Permanent
2.	Loloirien 1	Ol Donyo Orok	Permanent
3.	Loloirien 2	Ol Donyo Orok	Permanent
4.	Olootuka	Ol Donyo Orok	Permanent
5.	Noonchuta	Namanga	Permanent
6.	Imuguri 1	Namanga	Permanent
7.	Lolkumur	Namanga	Permanent
8.	Nkaimurunya	Namanga	Permanent
9.	Lolkokoyo	Namanga	Permanent
10.	Loloirien 3	Namanga	Permanent
11.	Miliara	Namanga	Permanent
12.	Elangata edapidapoi	Namanga	Permanent
13.	Imugurri	Namanga	Permanent
14.	Kipas	Namanga	Permanent
15.	Oloormotonyotik	Namanga	Permanent
16.	Enarusa	Namanga	Permanent
17.	Kilosokuan	Namanga	Permanent

The water resources in this ecosystem are faced with numerous threats ranging from erosion, siltation and pollution. Further, livestock overgrazing in the Water Tower during the dry season has led to the degradation of the water catchment which ultimately interferes with water quality and quantity flowing in the rivers and springs. For these reasons, there is an urgent need to conserve and protect this catchment area.

Namanga Spring Development and Protection

Spring development involves protecting both the spring and its water quality from environmental damage and contamination, as well as improving access to the water. Before a spring is developed, it is essential to check the quantity and quality of the water. The rate of flow should be reliable through all seasons.

Springs can be developed in two different ways; depending on whether it is a concentrated spring or a seepage spring. A concentrated spring occurs when groundwater emerges from one defined discharge in the earth's surface while Seepage springs occur when shallow groundwater oozes or "seeps" from the ground over a large area and has no defined discharge point.

Out of the seventeen springs mapped in Namanga Water Tower; Noonchuta, Olootuka and Lolorien 1 and Lolorien 2 springs could be considered for protection. A case in example is Olootuka spring.

Olootuka Spring

This is an artesian flow spring which emerges at a lower elevation as Lolorien1, Lolorien 2 and Ololdoomani, therefore it recharges the downstream springs. This type of spring offers an excellent supply of water.

Its proximity to the forest boundary exposes it to manual extraction of the water. Some of the ways to protect and conserve this spring would involve:

i. Excavation of the land upslope from the spring discharge to allow the water flow

ii. Installation of a rock bed to form an interception reservoir

iii. Construction of a collection concrete wall of downstream from the spring discharge

iv. Installation of a pipe below the collection wall to direct water from the interception reservoir to a spring box (collecting area)

v. Installation of (a) an overflow pipe to prevent a back-up in the spring, (b) an outlet pipe which can be connected to a storage tank and (c) a drain pipe which will allow the spring box to be cleaned periodically

vi. Removal of potential sources of contamination upslope of the spring discharge point and divert surface water away from the collecting area or spring box

vii. Fencing around the spring drainage area to keep animals from contaminating the water.

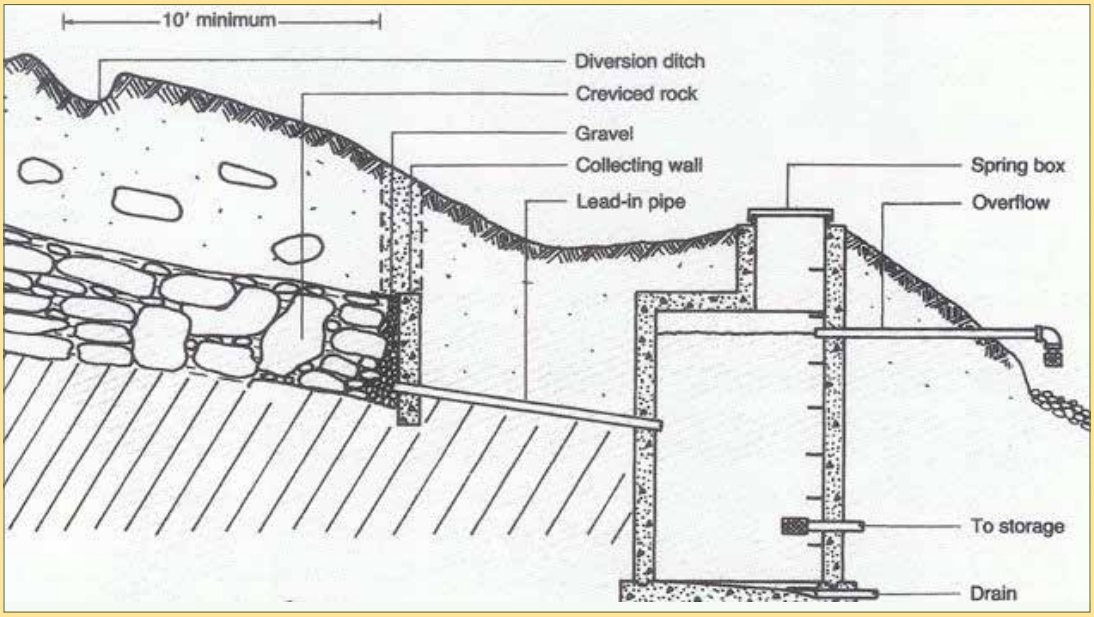


Figure 1: Development of a concentrated spring (Adapted from Safeguarding Wells and Springs from Bacterial Contamination, Department of Agricultural and Biological Engineering, The Pennsylvania State University

Maintenance of Springs

1) Remove sources of contamination

Whichever type of spring development, it is critical to remove all possible sources of contamination from the springs discharge area mainly the area upslope of the spring discharge point. Surface water draining into that area should be redirected and all activities should be limited within the drainage area. If livestock are present, fences should be used to keep animals from contaminating the drinking water supply.

2) Water testing and disinfection

Most springs used for drinking water will require some type of continuous disinfection system to make certain that the water is safe for consumption. Once the spring is developed and nearby sources of contamination are eliminated, it is important to disinfect the entire water system and then submit a water sample to a state certified water testing laboratory for water quality analysis. If a water test indicates bacterial contamination, the water supply location and construction of the system should be checked for potential pollution pathways. The system should then be shock chlorinated. After two weeks the water should be retested, if again it tests positive for bacterial contamination, a new source of water can be identified or a continuous disinfection system installed, such as an ultraviolet light.

2.3 Biodiversity

Namanga Hill Water Tower is an important biodiversity habitat thus a cradle of biodiversity. It has had minimal human disturbance. A total of 2,208 plant and animal species have been identified in the Water Tower (665 vascular plants, 42 mushrooms, 41 mammals, 140 birds, 1270 invertebrates, 38 reptiles and 12 amphibians).

***"If we pollute the air, water and soil that keep us alive and well, and destroy the biodiversity that allows natural systems to function, no amount of money will save us"* Author David Suzuki in 40 inspiring quotes on climate change, sustainable living and our natural environment.**

2.3.1 Vascular Plants

The 665 vascular plant species in the Water Tower belonged to 228 genera and 71 families of vascular plants are from *Leguminosae* family (10%) and Compositae (8%). Vascular plant species of conservation interest included; ***Dalbergia melanoxylon*** (Mpingo) valued for timber and has been heavily exploited for wood carving and medicinal purpose. ***Prunus africana*** tree has been listed as vulnerable in the IUCN red list. Other medicinal plants included *Aspilia mossambicensis, Vernonia lasiopus, Commiphora habessinica, Terminalia brownii, Olinia rochetiana, Scurtia myrtina, Toddali asiatica, Zanthoxylum chalybeum and Z. usambarense. Succulent plants included Aloe secundiflora, Cissus rotundifolius, C. quandrangularis, Euphorbia candelabrum, E. scheffleri and Kalachoe spp.* Some of the invasive weedy species were *Acanthospermum hispidum, Ipomoea hildebrandtii, Solanum campyracanthum and Argemone mexicaca.*

Plate 2.2: a) *Dalbergia melanoxylon* (Mpingo) b) *Zanthoxylum chalybeum*

2.3.2 Macrofungi (Mushrooms)

Forty two (42) macrofungi species were identified distributed in 19 genera and 10 families that existed in the Namanga Hill ecosystem. The macrofungi species were mainly from the ***Polyporaceae*** family with 17 species followed by ***Stereaceae*** and ***Ganodermataceae*** (6 species each), ***Hymenochaetaceae*** (3 species) and the rest of the families (***Inocybaceae, Meruliaceae, Schizophyllaceae and Xylariacea***) each with 1 species. There was a rich assemblage of wood decaying fungi (***basidiomycetes***) that grew on dead stumps, dead tree logs, fallen branches, twigs and living trees (Plate 2.3). As well, there were wild edible and medicinal mushroom species that included ***Schizophyllum commune, Volvariella volvaceae, Auricularia polytrica*** (Plate 7), ***Ganoderma lucidum*** (Plate 2.4).

Plate 2.3: Some Mushroom Species in Namanga Water Tower Ecosystem

Datronia mollis

Hexagonia tenuis

Lenzite elegance

Trametes polyzona

Cymatoderma elegance

Crepidotus sp

2.3.3 Reptiles and Amphibians

The richness of amphibian species was low since Namanga hill ecosystem is a dryland habitat. There were 38 reptile (3 tortoises, 18 lizards, 16 snakes) and 12 amphibian (frogs and toads) species in the ecosystem. ***Pyxicephalidae*** amphibian family was the most dominant with three species followed

Spongipellis sp

Pycnoporus cinnabarius

Plate 2.4: Wild Edible Macrofungi in the Namanga Ecosystem

by ***Bufonidae, Phrynobatrachidae*** and ***Ptychadenidae*** with 2 each and ***Hemisotidae, Pipidae*** and ***Rhacophoridae*** with one each.

The dominant reptile family was ***Lamprophiidae*** represented by the following snake species: Jackson's centipede-eater, Brown house snake, Keller's Bark Snake, Cape wolf snake, Dwarf sand snake, Olive sand snake and Northern stripe-bellied sand snake. The second and third most common reptile families were ***Gekkonidae*** (Geckos) and ***Scincidae*** (skinks) represented by six and five species respectively. The geckos recorded included Tropical house gecko, Nyika gecko, Forest gecko, East

African house gecko and Kenya dwarf gecko. On the other hand, the skinks included Sundevall's writhing skink, Wahlberg's snake-eyed skink, Short-necked skink, Tree skink and Variable skink. The fourth most dominant family was Elapidae.

Plate 2.5: Keller's bark snake

2.3.4 Birds

The water Tower had one hundred and forty (140) bird species distributed in Acacia woodland, closed forest and riparian habitats. The Acacia woodland habitat had one hundred and four (104) species characteristic of the somali-maasai biome endemic bird area. The closed forest habitat had forty-seven bird species out of which ten were forest specialists while the riparian gallery had forty (40) species. The forest specialist bird species in the cloud forest were; Lemon Dove, ***Aplopelia larvata, Hartlaub's Turaco, Tauraco hartlaubi,*** Grey ***Apalis, Apalis cinerea,*** Mountain Greenbul, ***Andropadus nigriceps,*** Stripe-cheeked Greenbul, ***Andropadus milanjensis,*** Cabanis's Greenbul, ***Phyllastrephus cabanisi,*** White-starred Robin, ***Pogonocichla stellate,*** Olive Sunbird, ***Cyanomitra olivacea,*** Mountain Buzzard, ***Buteo oreophilus*** and Crowned Eagle, ***Stephanoaetus coronatus.***

Grey-backed Camaroptera

Spot-flanked Barbet

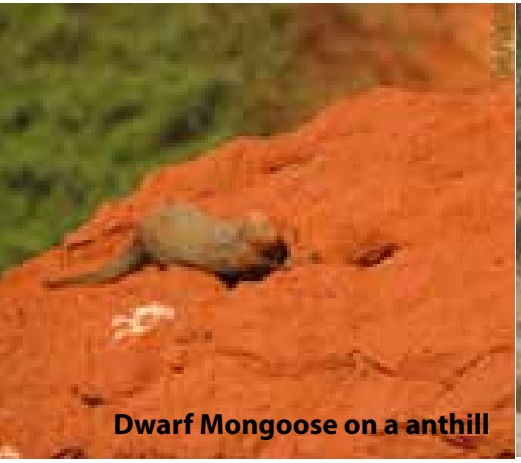
Crowned Eagle

White-bellied Go-away-bird

2.3.5 Mammals

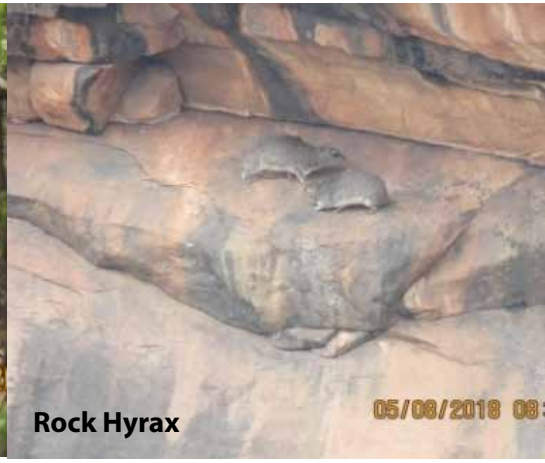
A total of 41 mammal species were confirmed to occur in Namanga Hill Water Tower. Even toed ungulates (18) had the greatest number of species, followed by carnivores (8) and rodents (4). One mammal species was listed as Endangered (EN), four vulnerable (VU), two Near-threatened (NT) and 34 as Least Concerned (LC) 34) in the IUCN Red List of Threatened species.

Most of the mammal species were observed in more open lowlands areas, dominated by ***Acacia-Commiphora*** bush lands and thickets below 1600 meters above sea level but rarely beyond this altitude due to dense bush undergrowth. Some of the large mammals species observed were Leopard (***Panthera pardus***), African Buffalo (***Syncerus caffer***), Bushbuck (***Tragelaphus sylvaticus***), Maasai Giraffe (***Giraffa camelopardalis***), Zebra (***Equus quagga***), Grant's Gazelle (***Nanger granti***), Common Eland (***Taurotragus oryx***), Warthog (***Phacochoerus africanus***), African Wild dog (***Lycaon pictus***), Spotted hyena (***Crocuta crocuta***), Olive baboon (***Papio Anubis***), Coke hartebeest (***Alcelaphus buselaphus***), Thomson's gazelle (***Gazella thomsonii***), Impala (***Aepyceros melampus***), Common Waterbuck Kobus (***Ellipsiprymnus spp***), Common Wildebeest (***Connochaetes taurinu***s), Dik dik (***Madoqua kirkii***), Common Bush Duiker (***Sylvicapra grimmia***), Fringe-Eared (***Oryx Oryx beisa***), Gerenuk (***Litocranius walleri***), Lesser Kudu (***Tragelaphus imberbi***s), Cheetah (***Acinonyx jubatus***), Lion (***Panthera leo***), Silver Backed Jackal (***Canis mesomelas***) and Reedbuck (***Redunca redunca***).



Dwarf Mongoose on a anthill

Olive Baboon, very common in lowland and high altitude area of the forest



Rock Hyrax

Plate 2.7: Some Mammal Species in Namanga Hill.

2.3.6 Invertebrates

A total of 1,270 invertebrate species belonging to 8 orders have been recorded in the Water Tower. The orders were Hymenoptera (487), Lepidoptera (458), Diptera (212), Hemiptera (47), Coleoptera (43), Orthoptera (18), Phasmatodae (3) and Mantodae (2). Order Diptera, Coleoptera, Lepidoptera and Hymenoptera had seven families each, Hemiptera had six families; Orthoptera had four families while Mantodae and Phasmatodae had one family each. ***Nymphalidae*** and ***Pieridae*** families had the highest number of genera (25) followed by Formicidae with 12 and Pentatomidae with 8 genera. In regard to species richness and landscape orientation, the windward side of the hill had 98 species while the leeward side had 89 species.

Plate 2.8: Charaxes zoolina: they exhibit background matching in grassland Savannah

Plate 2.9: Diptera as pollinators: New area of exploration

Plate 2.10: Formicidae ants: Models for phenyl acetic acid organic spray for fungi and bacteria control

Plate 2.11: Apis mellifera in pollination: it is under threat of habitat destruction and inorganic pesticides.

A B

Plate 2.12: A) Sweat bees and B) Stingless bee in pollination

Plate 2.13: Termite mould: Model for house ventilation

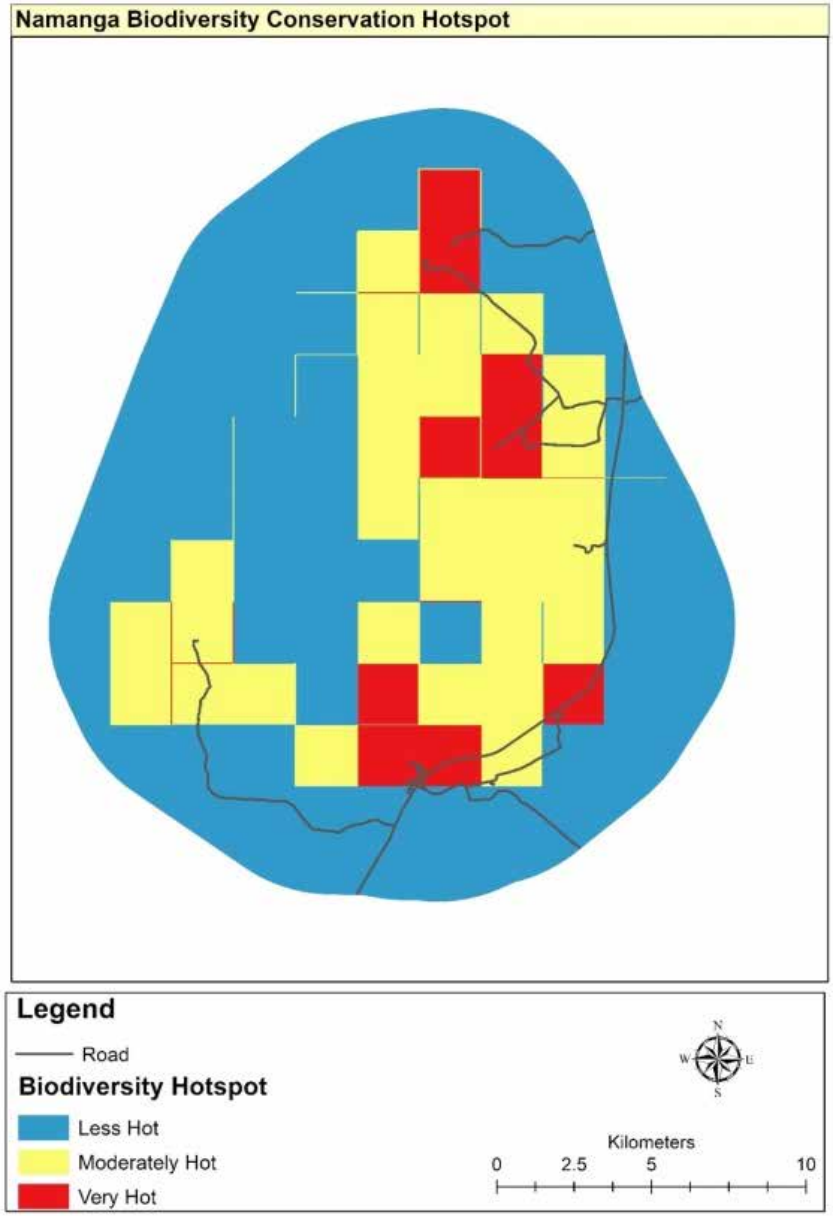


Figure 2.4: Overall Biodiversity Hotspots

2.3.7 Biodiversity Hotspots

Biodiversity hotspot maps show the areas with high species richness but prone to disturbances posing a threat to the species diversity across the water tower ecosystem (Figure 2.5). The biodiversity hotspots in the Namanga ecosystem are located in around Maili Tisa town, Namanga and border of Tanzania and Kenya. Most of the biodiversity hotspots are around the buffer zone while inside the forest, it is moderately hot. The western part of the hill has less threats and diversity where grazing is carried out intensively.

2.4 Socio-economic and Livelihoods

Namanga water tower provides basic goods for sustenance of local communities such as wood for local construction, firewood and pasture for communal grazing.

Pastoralism forms major source of livelihood of the Maasai community. The Water Tower provides grazing ground and water for livestock. The animals kept include indigenous cattle, sheep, donkeys and goats. These animals are taken into the forest during prolonged dry seasons when pasture and water are scarce without considering the carrying capacity leading to degradation.

The local communities also depend on the hill for water because of the existence of various rivers, springs, boreholes and shallow wells. Boreholes and shallow wells are recharged through water seepage to the underground system.

There is little sedentary agriculture. Common crops grown include maize, beans, watermelons, pawpaw, tomatoes, oranges and avocadoes. The average land size for the settled communities ranged from 5-10 acres. The community also owned Mailwa and Ol Donyo Orok group ranches. Few households had non-farm small-scale business such as selling of charcoal, firewood, honey, medicinal herbs and wood carving. ***Dalbergia melanoxylon*** (Mpingo tree) is over extracted for wood carving.

2.4.1 Population

According to the 2009 National Housing and Population Census, Namanga Hill Water Tower had a population of 20,749 where 10,323 are women and 10,426 are men. Namanga location had the highest population at 18,515 and Mailwa with the lowest of 2,234 (Table 2.2). The Water Tower is largely inhabited by the Maasai community. The overall population density was 27 people per km^2. Namanga location had the highest population density at 32 people per km^2 while Mailwa location the least at 11 people per km^2 (Figure 2.6).

Table 2.2: Population for Locations within Namanga Hill

Location	Male	Female	Total	Households
Mailwa	1,048	1,186	2,234	475
Namanaga	9,378	9,137	18,515	4,125
Total	**10,426**	**10,323**	**20,749**	**4,600**

"We have the capacity to create a remarkably different economy: one that can restore ecosystems and protect the environment while bringing forth innovation, prosperity, meaningful work, and true security" ***Author Paul Hawken in 40 inspiring quotes on climate change, sustainable living and our natural environment***

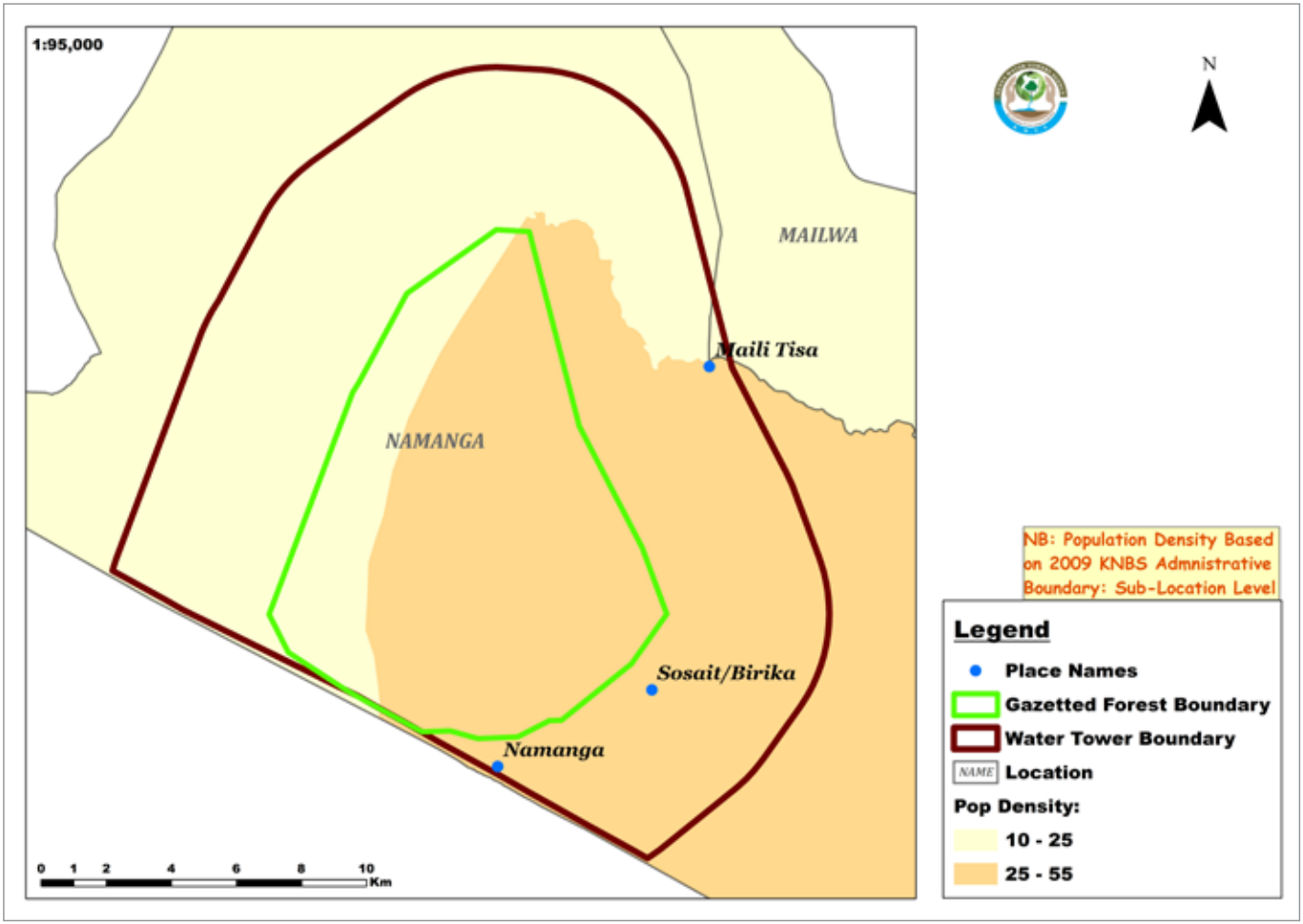


Figure 2.5: Population Density for Locations within Namanga Hill.

2.5 Land Use and Land Cover

In Namanga Hill Water Tower, shrub-land was the most dominant LULC at 67% followed by forest land (23%) as can be seen in Table 2.3. Cropland and built up areas occupied 2.5% of the total Water Tower. In the gazetted forest, cropland covered 29 ha and settlement 9 ha as result as of encroachment (Table 2.3). This implies a potential threat of disruptive human activities on the Water Tower ecosystem health and resilience unless appropriate preventive measures are undertaken.

Table 2.3: Land Use Land Cover Status for Namanga Hill Water Tower in 2017

LULC Type	Area Covered (ha)		Total Area (ha)
	Gazetted Forest	Buffer Zone	
Shrub land	3,152	24,315	**27,467**
Forest	8,701	721	**9,422**
Grassland	15	3,312	**3,327**
Cropland	28.7	523	**552**
Built up	5.9	483	**489**
Wetland	0.0	0.4	**0.4**
Total	**11,903**	**29,355**	**41,258**

By 2018, the forestland within the buffer zone had increased by 37.9 % (from 6,832 to 9,422 ha) while grassland declined by 10% (34,417 to 30,793 ha). The decline could be attributed to overgrazing and the condition has been exacerbated by the changing climatic conditions in area. (Figure 2.7; Figure 2.8; Figure 2.9).

"The wounds we have inflicted on the earth can be healed… but if it is to be done, it must be done now. Otherwise it may never be done at all" Author Jonathon Porritt in 40 inspiring quotes on climate change, sustainable living and our environment"

Cropland has also increased by 47% (11.8 ha in 2000 to 552.9 ha in 2018 and this is attributed to change of livelihood from nomadic to sedentary with small scale farming practices. Some local communities have changed their pastoralist lifestyle and adopted sedentary life where they practice small scale agriculture.

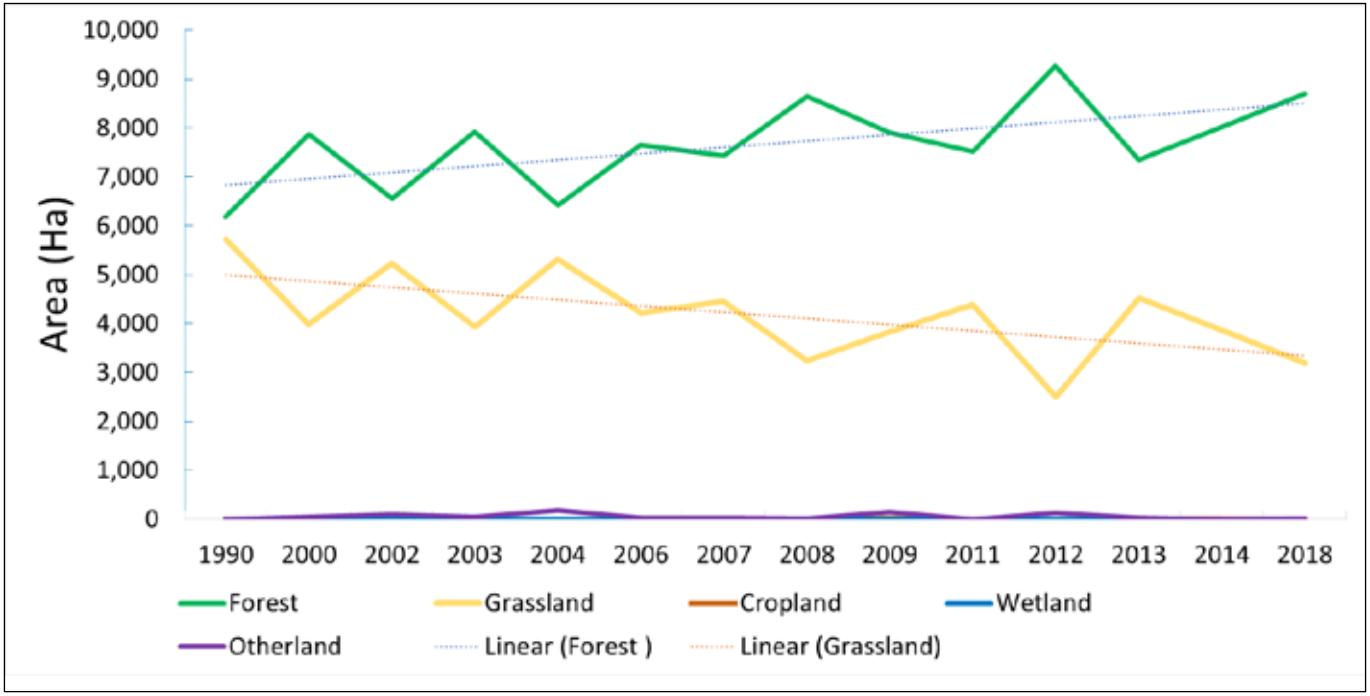


Figure 2.6: Land Use Land Cover Trends in the the gazetted forest

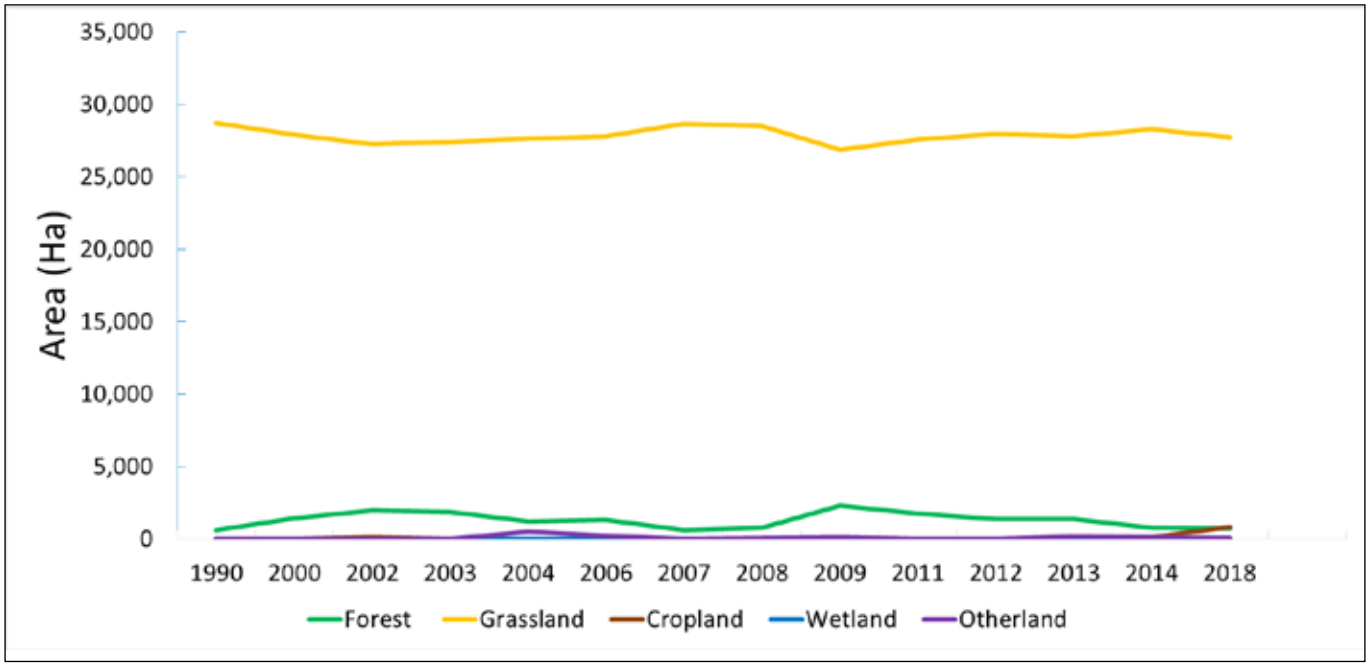


Figure 2.7: Trend for Forestland in the Buffer Zone of Namanga Hill.

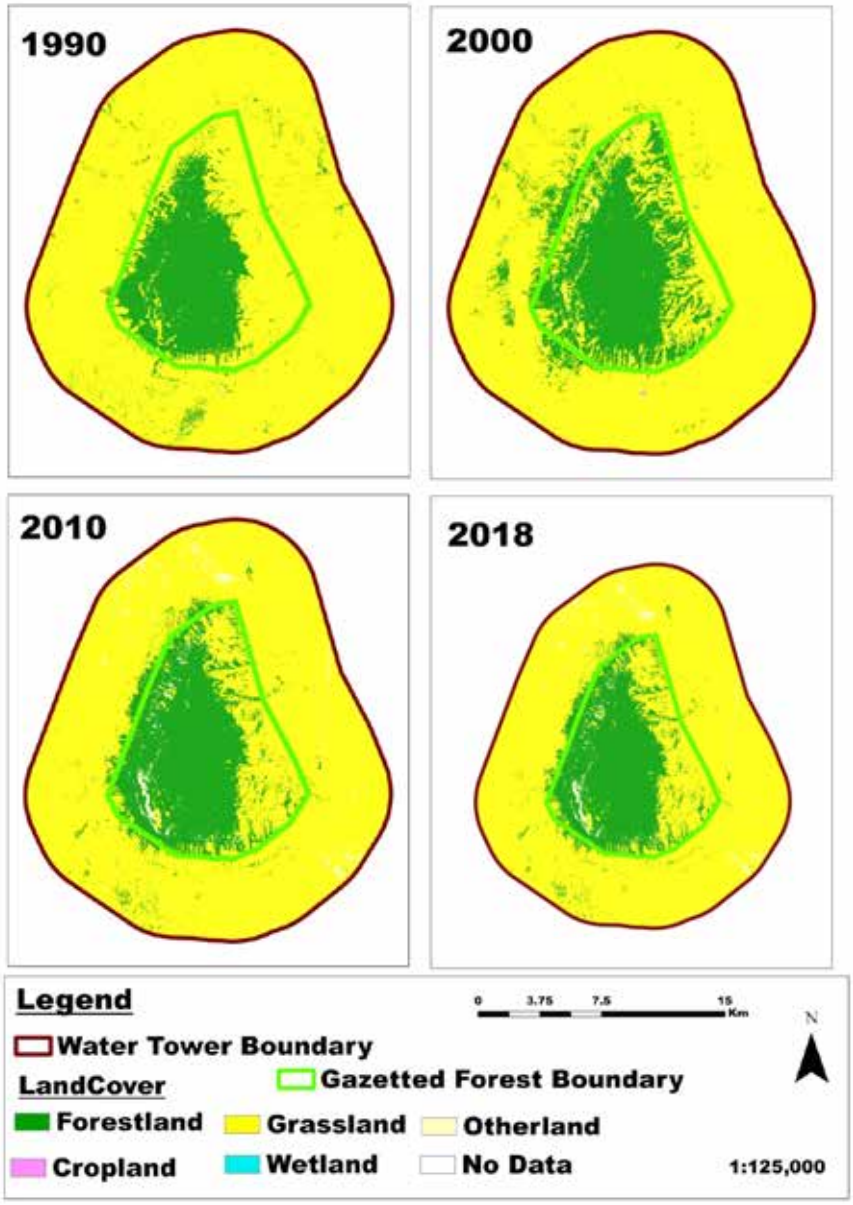


Figure 2.8: Namanga Hill Land Use Land Cover Trends between 1990-2018

2.6 Economic Valuation

Economic valuation for Namanga hill Forest was carried out in 1996 by African Wildlife Foundation (AWF) covering only the provisioning services. The Participatory Environmental Valuation (PEV) method based on linkages between local economic systems and cash values was used to elicit information about forest use and values at the subsistence and non-market level.

Namanga forest was valued at about $100 a year for each local household for grazing and water as the main ecosystem services and products (Table 2.4). The annual benefits of forest use for both ecosystem goods and services were about KES. 5,000 for every household neighboring the forest. The total annual economic value of the water tower was about KES. 2.4 million to the communities surrounding the forest which justifies conservation and protection of the Water Tower.

Since the economic valuation only focused on provisioning services and are outdated, there will be need to conduct total economic valuation and determine the current economic value.

Table 2.4: Annual Forest Use Values for Forest-Adjacent Households

Forest Activity	Percent of households	(Kshs/year)		95% Confidence intervals
		Average Value	Median value	
Grazing	95	1.130	947	1.128-1.133
Water	95	995	1.052	992-998
Fuelwood	90	596	584	593-596
Construction	89	748	762	743-750
Medicines	85	565	573	562-568
Honey	64	468	435	465-472
Hunting	58	265	234	261-269
Wild foods	49	156	117	150-162
Utility items	43	302	333	295-309
All activities	-	4,778	4,778	4,775-4,780

Source: AWF report, 1996 (RDFN Paper 19e, Summer 1996)

2.7 Stakeholder Interaction with the Water Tower

The stakeholders of Namanga Hill Water Tower were classified into three main categories: the state actors, non-state actors and the local communities.

Key state and non-state stakeholders within the water tower and their functions are presented in Table 2.5.

Table 2.5: State and non-State stakeholders and their Functions

No.	Institutions	Functions
State Actors		
1.	Kenya Water Towers Agency	- To coordinate and oversee the protection, rehabilitation, conservation and sustainable management of all the water towers in Kenya
2.	Kenya Forest Service (KFS)	- To enhance development, conservation and management of Kenya's forest resources base in all public forests, and assist County Governments to develop and manage forest resources on community and private lands for the equitable benefit of present and future generations

No.	Institutions	Functions
State Actors		
3.	Kenya Wildlife Service (KWS)	- To conserve and manage wildlife in Kenya, and to enforce related laws and regulations
4.	National Environment Management Authority (NEMA)	- To exercise general supervision and coordination over all matters relating to the environment and to be the principal instrument of the Government of Kenya in the implementation of all policies relating to the environment
5.	Water Resources Authority (WRA)	- To safeguard the right to clean water by ensuring that there is proper regulation of the use of water resources, in order to ensure sufficient water for everyone- now and in the future
6.	County Government of Kajiado	- To work in collaboration with National Government in the protection and management of resources at the County level
7.	Ministry of Interior and Coordination of National Government	- To support in administrative matters related to activities/ projects being undertaken in their area of jurisdiction. This also includes conservation activities.
8.	Ol Donyo Orok Water and Sanitation Services	- Provision of water to the community around the Water Tower
Non-State Actors		
9.	Ol Donyo Orok Community Forest Association (CFA)	Creation of awareness and community sensitization on conservation and participate in local management of the forest

No.	Institutions	Functions
9.	Water Resource User Association (Namanga and Ol Donyo Orok)	Engage in community sensitization on conservation and management of water resources
10	Mailwa Community Woodland Resources Association	Manage and conserve community forest
11.	Mailwa and Ol Donyo Orok group ranches:	Help in management and conservation of the forest through sensitizing the communities

2.8 Degradation Level in Namanga Hill Water Tower

The highest level of degradation in Namanga Hill Water Tower was categorised as high, medium and low based on visual observation with the highest level of of degradation observed at 60.3 %, Medium (38.5%) and low (1.3%).

The main causal factors for degradation were erosion and sedimentation (Figure 2.10) leading to development of gullies (Plate 2.2). Erosion had negatively affected soil productivity, restricted land use and destroyed infrastructure such as roads, fences and buildings. The Eastern and Southern sectors of the Water Tower recorded the highest density of active gullies (Figure 2.11).

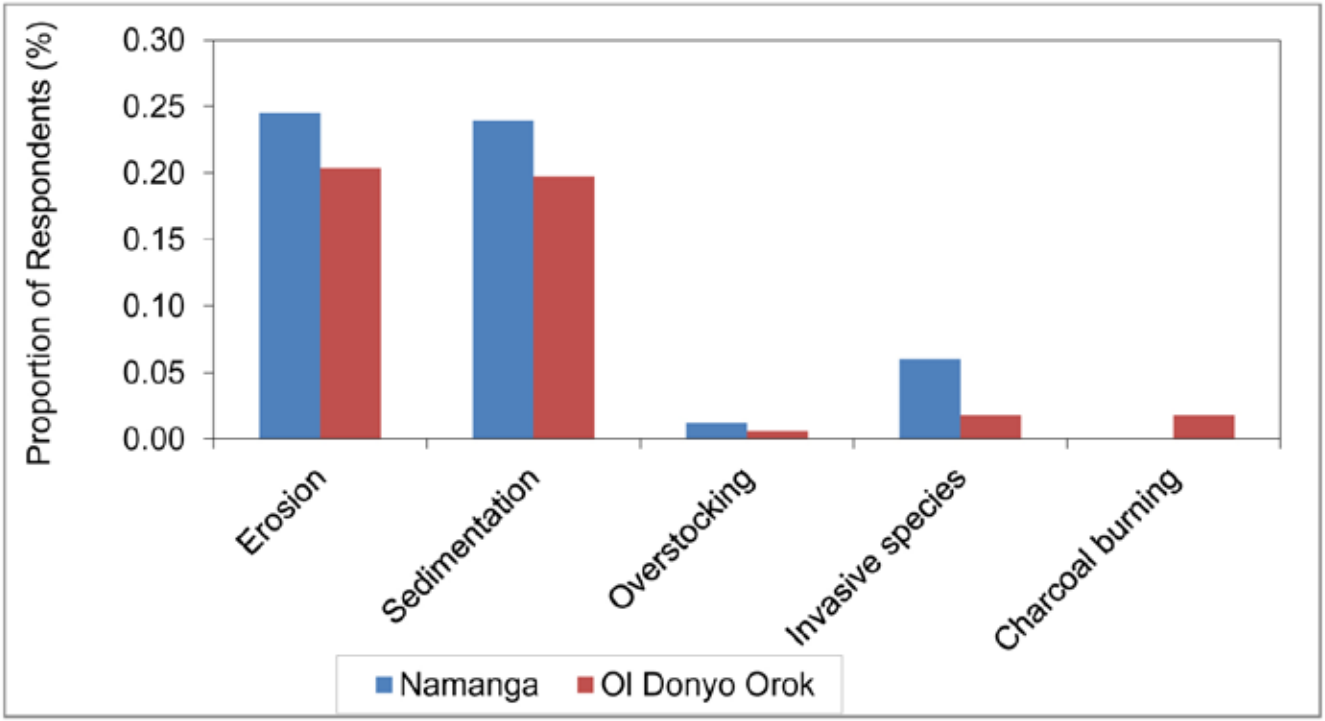


Figure 2.9: Drivers of Degradation in Namanga Hills Water Tower

Plate 2.14: Gully Erosion in the Buffer Zone of Namanga Hill.

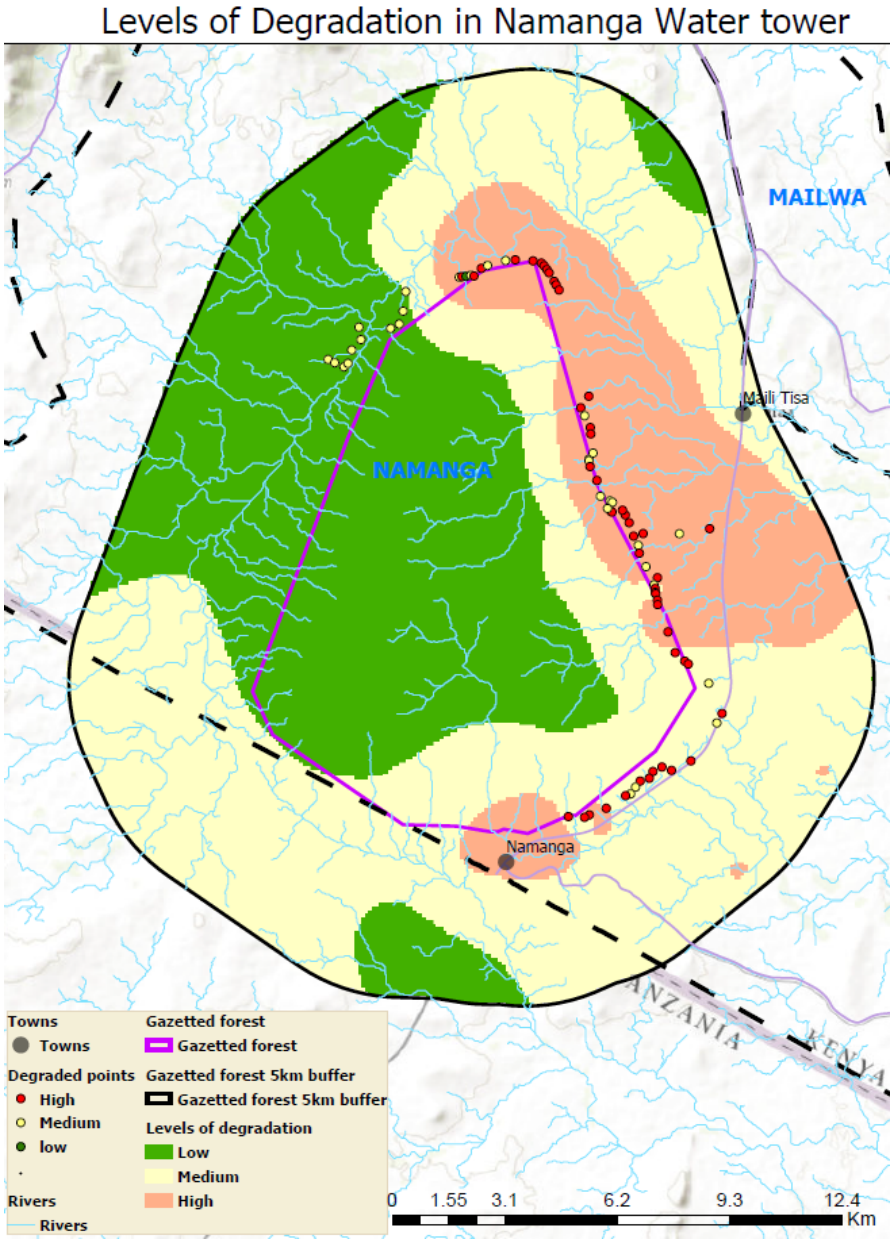


Figure 2.01: Map Showing Degradation Levels in Namanga Hill.

2.9 Threats and Challenges

The following were the major threats and challenges facing Namanga hill Water Tower:

1. Gulley erosion

This is the major threat being experienced in the Water Tower, especially on the Eastern and Southern side. This form of degradation is manifested through development of large gulleys that has affected soil productivity, restricted land use as well as threatening destruction of roads, fences and buildings. These gullies are as a result decreased or sparse land cover that will enhance soil resistance to erosion.

2. Overgrazing

The local Masaai community keep large herds of livestock without regard to the land carrying capacity. Inevitably large herds of livestock result in overstocking which hampers proper regeneration of vegetation cover within the Water Tower. During extreme drought periods, the local community cut down tree branches to feed their livestock hence destroying the ecosystem. In addition, they graze their livestock inside the Water Tower hence trampling on young seedlings as well as clearing of forest vegetation to create temporary shelters bomas in the Water Tower.

3. Prolonged drought

Frequent and prolonged drought experienced in the arid and semi-arid Water Tower ecosystem have aggravated due to the negative impacts of climate change. The intense and frequent droughts have reduced water quantity and quality and limited gazing areas for the livestock due to loss of vegetation. In addition, prolonged drought has also triggered conflicts over access to and control over limited available natural resources such as water and pasture.

4. Unclear forest boundary

The forest boundary for Namanga Hill Forest has been demarcated. However, beacons have been placed 7km apart making it difficult for local communities to locate the exact gazzeted area boundary between the beacons. In addition, the demarcation beacons were installed several years back and some have been lost leading to forest encroachment.

5. Invasive species

The buffer zone ecosystem is threatened with encroachment by invasive species such as Ipomea (***Ipomoea hildebrandtii***)., Khaki weed (***Alternanthera pungens kunth***) and Solanum (***Solanum campyracanthum***). These invasive species have reduced the local plant species diversity especially on pasture land hence impacting negatively on pasture availability and biodiversity.

6. Unsustainable charcoal production

Charcoal burning was concentrated in Oldonyoo Orok location in Enkolili, Lositeti and Oleisuswa villages. However, concerted efforts by KFS officials in promoting sustainable forest management activities to curb forest destruction has helped to reduce the occurrence of this problem. There is a need therefore for increased patrols and surveillance to control cross border charcoal trade.

7. Low level of awareness

Low level of awareness coupled with high level of illiteracy of the local communities has affected implementation of conservation and protection activities within the Water Tower. For instance, farmers in the area do not engage in agroforestry activities within their farms but instead practice slash and burn activities for land clearance. Most farmers regard trees as a hindrance to agricultural production.

8. Human-wildlife conflict

Human wildlife conflicts have increased over time due to encroachment into the wildlife habitat, blockage of wildlife corridors especially between Amboseli and Namanga hill and competition of water and pasture by domestic animals and wildlife. The conflict has negatively affected wildlife conservation efforts by the community due to increased cases of poaching and loss of livestock due to predation.

2.9 Proposed Interventions

1. Installation of more beacons along the boundary

Currently beacons demarcating the boundary of the Namanga gazetted forest are located 7km apart. To curb the threat of encroachment, there is need to increase the number of beacons.

2. Capacity building of CBOs

Strengthening the Community Forest Association and Water resources Users Association through capacity building such as promotion of bee keeping, development of ecosystem management plans and incentive in protecting and management of the Water Tower.

3. Creation of awareness and sensitization

Community sensitization on the benefits of forest conservation and management is important through involving local communities in conservation activities such as tree planting and employment of community scouts to work closely with KFS officers to monitor and conserve the forest.

4. Improving infrastructure and resource facilitation

Improving infrastructure such as roads would create accessibility around the Water Tower by the KFS rangers improving patrols and surveillance. In addition, there is need to increase the number of vehicles at the disposal of KFS rangers to improve their efficiency and effectiveness.

Also, increase in KFS outpost stations from two to four would help in protection and management of Water Tower. Finally, supply of piped water to the downstream communities should be done to deter people from getting into the hill in search of water for domestic and livestock watering.

5. Promotion of alternative source of livelihood

Introduction of programs that support other livelihoods such as alternative sources of energy sources of energy would reduce the dependence of firewood and charcoal as the main source of energy e.g. biogas since local communities keep large herd of cattle that produce manure that can be used to generate biogas. Also, establishment of tree nurseries would provide seedlings to both local communities and other institutions involved in management and conservation of the forest.

6. Rehabilitation of degraded areas

Support reforestation and afforestation activities in the Water Tower, especially on the Eastern and Southern part of the Water Tower. This would reduce the rate at which gulley erosion is being experienced in the area.

Table 2.6: Summary of Threats and Challenges and Proposed Interventions

Threats	Impacts	Intervention
Encroachment	1. Loss of biodiversity 2. Habitat fragmentation 3. Human-human and human-wildlife conflicts (migration) 4. Clearing of tree for pasture to grow 5. Destruction of riparian lands	1. Reclamation of encroached areas 2. Sensitization 3. Alternative livelihood programs (hay production) 4. Reforestation 5. Ecosystem management plan + Grazing plans 6. Law enforcement 7. Sustainable agriculture
Overstocking	1. Degradation (Erosion) 2. Loss of biodiversity 3. Overgrazing 4. Human wildlife conflicts 5. Spread of diseases (tracom) 6. Increased turbidity	1. Sustainable livestock management programs (improved breeds, paddocking) 2. Law enforcement (prohibit grazing in forest) 3. Capacity building 4. Reforestation 5. Development of livestock business plan
Prolonged drought	1. Overuse of resources 2. Conflicts over resource use 3. Vicious cycle of poverty	1. Adaptive livelihoods (drought resistant grass)

Threats	Impacts	Intervention
Unclear Forest Boundary (beacons are a distant apart 7km)	1. Encroachment 2. Loss of biodiversity 3. Habitat fragmentation 4. Human-human and human-wildlife conflicts (migration) 5. Clearing of tree for pasture to grow 6. Destruction of riparian lands	1. Additional beacons 2. Eviction 3. Sensitization 4. Alternative livelihoods (hay) 5. Reforestation 6. Ecosystem management plan + Grazing plans 7. Law enforcement 8. Sustainable agriculture
Charcoal	1. Forest fires 2. Loss of biodiversity 3. Erosion 4. Carbon emission	1. Ban charcoal burning 2. Joint enforcement
Low level of awareness	1. No interest in conservation 2. Habitat destruction 3. Biodiversity loss 4. Over exploitation of resources	1. Sensitization 2. Rehabilitation of destructed sites 3. Law enforcement

Threats	Impacts	Intervention
Human – wildlife conflicts	1. Loss of biodiversity 2. Crop and livestock destruction 3. Red tape in process of compensation 4. Economic values	1. Coordination with KWS 2. Sensitization 3. Promotion of eco-tourism 4. Increase KWS staff

3.0 Proposed Implementation Matrix

Based on threats and challenges, the recommended intervention measures and profile of key stakeholder in Elgeyo Hills Water Tower, a proposed implementation plan has been developed. The Plan estimates a budget of KES 262 Million that will be required for restoration and conservation of this Water Tower.

No	THREATS	INTERVENTION(s)	PERIOD	INDICATIVE BUDGET (Ksh. Million)	IMPLEMENTATION BODY	EXPECTED OUTCOME
1.	**Low level of awareness on water tower conservation among the local community**	Enhance Sensitization and community awareness on water tower conservation	Continuous	8*	Ministry of interior and Coordination of National Government, KWTA, KFS, CFA, Group ranches, NEMA, County Government of Kajiado, WRA	Enhanced level of awareness of conservation of the water tower.
		Capacity building on nature-based strategies such as bee keeping, bamboo enterprise	3 years	20	KFS, KWTA, NEMA, CFA and county Government of Kajiado	Increased participation in conservation activities within the water tower

No	THREATS	INTERVENTION(s)	PERIOD	INDICATIVE BUDGET (Ksh. Million)	IMPLEMENTATION BODY	EXPECTED OUTCOME
2.	**Soil erosion**	Gulley rehabilitation	3 years	10	KWTA, KFS, County Government of Kajiado, Department of Agriculture, NEMA,	Soil conserved
		Tree planting	3 years	12	KFS, KWTA, NEMA, KWS, WRA, County Government of Kajiado, NGO's and CSO's Youth Groups	Enhanced soil quality and stability

No	THREATS	INTERVENTION(s)	PERIOD	INDICATIVE BUDGET (Ksh. Million)	IMPLEMENTATION BODY	EXPECTED OUTCOME
3.	**Overgrazing**	Development and implementation of grazing plans	2 years	15	KFS, CFA, Group ranches, KWTA, NEMA, County Government of Kajiado, Ministry of Agriculture	• Improved biodiversity richness and quality • Soil conserved
		Promotion of sustainable livestock management programs such as improved livestock breeds, hay production	5 years	20	KWTA, KFS, CFA, County Government of Kajiado, NGOs	• Reduced reliance on forest products • Improved vegetation regeneration • Increased livestock productivity hence increased household income

No	THREATS	INTERVENTION(s)	PERIOD	INDICATIVE BUDGET (Ksh. Million)	IMPLEMENTATION BODY	EXPECTED OUTCOME
4.	**Unclear Forest boundary**	Boundary realignment and beaconing.	3 years	20	KFS, county government of Kajiado, KWTA, Survey of Kenya, Ministry of interior and coordination.	Enhanced protection, management and conservation of the water tower
5.	**Spread of Invasive species such as (*Ipomoea hildebrandtii*)., Khaki weed (*Alternanthera pungens kunth)* and Solanum (*Solanum campyracanthum)***	Development and implementation of ecosystem management plan	5 years	30	KWTA, KFS, NEMA, KWS, WRA, KEFRI, County Government of Kajiado, Ministry of interior and coordination, NGOs	Improved conservation and management of the ecosystem.
		Removal of invasive species	3 years	20	KFS, CFA, Group ranches, KWTA, NEMA, County Government of Kajiado, WRA, Ministry of interior and Coordination, KEFRI, NGO's	Improved biodiversity quality.

No	THREATS	INTERVENTION(s)	PERIOD	INDICATIVE BUDGET (Ksh. Million)	IMPLEMENTATION BODY	EXPECTED OUTCOME
		Reseeding	2 years	12	KFS, CFA, Group ranches, KWTA, NEMA, County Government of Kajiado, WRA, Ministry of interior and Coordination, KEFRI, NGO's	Enhanced species richness.
6.	**Charcoal production**	Promotion of alternative sources of clean energy such as, briquettes efficient and energy saving jikos,	3 years	10	KWTA, County government of Kajiado, CFA, KFS, ministry of energy	Forest cover and biomass improved.
		Enforcement of charcoal production regulations and guidelines	4 years	5	KFS, CFA, Group ranches, KWTA, NEMA, County Government of Kajiado, WRA, Ministry of interior and Coordination, KEFRI, NGO's	Enhanced protection and conservation of water tower resources.

No	THREATS	INTERVENTION(s)	PERIOD	INDICATIVE BUDGET (Ksh. Million)	IMPLEMENTATION BODY	EXPECTED OUTCOME
7.	**Human Wildlife conflict**	Fencing of human-wildlife hotspot areas	5 years	20	KWS, County government of Kajiado, KWTA, KFS, NEMA	Reduced human wildlife conflicts
8.	**Lack of legal and coordination framework**	Facilitation of conservation committees	Continuous	10*	Ministry of Interior and Coordination, KWTA, NEMA, KFS, KWS, WRA, KMD, County government of Kajiado,	Enhance synergies in protection, conservation and management.
		Development and implementation of Ecosystem Management Plans and monitoring plans	5 years	50	KWTA, Ministry of Interior and Coordination, NEMA, KFS, KWS, WRA, KMD, County government of Kajiado, CFAs, WRUAs	Improved conservation of water towers
GRAND TOTAL				**262**		

N/B: * Annual Budget

4.0 Conclusion and General Recommendations

Namanga Hill Water Tower borders Namanga town at the Kenya-Tanzania border covering a total area of 41,258ha. The climate for Namanga hill is arid and semi-arid with an average temperature of 20.8^{0}C and annual rainfall in the range of 300-800 mm having a bimodal distribution pattern. Namanga hill is a source of five rivers (three permanent and two seasonal) and 17 springs. The hill had experienced minimal human disturbance and was therefore an important habitat to millions of animal and plant species, thus a cradle of biodiversity. The estimated annual economic value of of provisioning services for the Water Tower was KES. 2.4 million based on an assessment carried out in 1996. Some of the key threats for Namanga hill are land degradation, overstocking, climate change, unclear forest boundary, charcoal burning and human-wildlife conflict. The following priority interventions are proposed to ensure overall ecosystem health and resilience of this water tower:

(i) **Carry out total economic valuation of goods and services** of Namanga

(ii) **Enforcement of existing laws and regulations**;

(iii) **Develop Ecosystem Management Plans** to promote partnerships and linkages amongst stakeholders involved in the conservation and management of the two ecosystems;

(iv) **Proper demarcation of water tower boundaries** to discourage encroachment and further excision;

"Until you dig a hole, you plant a tree, you water it, and make it survive, you haven't done a thing. You are just talking" ***Author Wangari Maathai in 40 inspiring quotes on climate change, sustainable living and our environment***

(v) **Creating awareness and promoting participation of local communities** through sensitization on the importance of conserving the Water Towers' ecosystem health and resilience

(vi) **Introduction of alternative sources of livelihoods** and sources of energy to reduce overdependence on the natural resources from the Water Towers by the local communities

Appendix I: List of preferred tree species for rehabilitation and their uses in Namanga Hill Water Tower

No	Purpose	Local Name	Common Name	Botanical Name
1.	**Charcoal**	Oiti	Black thorn	*Acacia mellifera*
		Oltepesi	Umbrella thorn	*Acacia tortilis*
		Osaragi/Orngóswa	-	*Balanites glabra*
		Ilera	-	-
		Osiyiamalili	-	-
		Oluai	Whistling thorn	*Acacia drepanolobium*
		Olerai	Flood plain acacia	*Acacia kirki*
2.	**Firewood**	Ol- lerai	Flood plain acacia	*Acacia kirki*
		Oiti	Black thorn	*Acacia mellifera*
		Osiyiamalili	-	-
		Oltepesi	umbrella thorn	*Acacia tortilis*
3.	**Construction/ building**	Oiti	Black thorn	*Acacia mellifera*
		Olkiloriti	Gum arabic tree	*Acacia nilotica*
		Oiri	White cross-berry	*Grewia tenax*
		Esambukike	-	-
		Eseki	Sandpaper tree	*Cordia monoica*
		Ositeti	False brandybush	*Grewia bicolor*
		Olporokuai	-	-
		Olgilai	Small-fruited teclea	*Vepris mobilis*

No	Purpose	Local Name	Common Name	Botanical Name
4.	**Medicinal plants**	Olkinyie	Diamond-leaved euclea	*Euclea divinorum*
		Orkokola	Buckthorns	*Rhamnus staddo*
		Olkonyil	Dogwood	*Rhamnus prinoides*
		Oremit	Toothbrush tree	*Salvadora persica*
		Oledat	Wild-mulberry	*Trimeria grandifolia*
		Olosesia	Bark bush	*Osyris abyssinica*
		Olkinyei	Magic guarri	*Euclea divinorum*
		Orkirenyi	-	*Olinia rochetiana*
		Enjan-Engashe	-	*Turraea spp*
		Entotoniki	East African greenheart	*Warbugia ugandensis*
		Olaimuranyai	Abyssinian Gooseberry	*Dovyalis abyssinica*
		Ormabait	-	-
		Oiti	Black thorn	*Acacia mellifera*
		Entipiliwua	-	-
		Oltimigomi	Cape pappea	*Pappea capensis*
		Esukuroi-Enkejunabo	-	-
5.	**Wood carving**	Oloiren	African wild olive	*Olea europaea*
		Oiti	Black thorn.	*Acacia mellifera*

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