

Kenya Water Towers Status Report Mwangea Hills



Coordinated Water Towers Conservation
2019 - 2020 (3rd Quarter)

Kenya Water Towers Status Report

for
Mwangea Hills



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Statement by the Cabinet Secretary



The Government of Kenya is committed to provide clean and health environment to its citizens as articulated in the Constitution. This is further supported by various national strategies such as The Kenya Vision 2030 and the Big Four Agenda. One of the social pillars of the Kenya Vision 2030 provides for access to water and sanitation for all by 2030. To achieve this, Water Towers plays significant role since it is a source of 75 percent of the renewable surface water resources in Kenya. They also act as enablers for the achievement of the Big Four Agenda on food security, affordable housing, manufacturing and affordable healthcare.

To ensure these ecosystems are well protected, the Government established Kenya Water Towers Agency with a mandate of coordinating and overseeing conservation, rehabilitation and sustainable management of Water Towers in the Country. We are also committed to reclaiming, rehabilitating and restoring all encroached forest lands which are the receptive sections of the Water Towers. Mwangea Hill Water Tower is a key catchment area for Athi-Galana/Sabaki River; the longest river in Kenya. River Galana is the main source of water supporting the Galana-Kalalu irrigation project; one of the key projects under the Big Four Agenda.

The Water Tower has been highly encroached as a result of farming and settlement. The once mist forest has been reduced to farmlands hence losing its ecosystem connectivity with Tsavo and Arabuko Sokoke forest. I strongly believe that with concerted efforts and synergy among stakeholders, the integrity of this water tower can be restored mainly through rehabilitation of the degraded areas. I therefore call upon all the stakeholders in the Government (National and County), Non-Governmental Organization, Community Based Organizations and the private sectors to join forces to restore and protect these critical ecosystems. I acknowledge conservation efforts that have been implemented in this Water Tower since 2014. This has seen an increase in forest cover by 2,136 ha which was largely contributed by community participation in

agroforestry. I encourage everyone to embrace this culture of growing trees in support of the Governments' plan on planting trees aimed at achieving 10% of forest cover by 2022.

My Ministry will provide the necessary support towards conservation of Mwangea Hill Water Tower.

A handwritten signature in black ink, consisting of several overlapping loops and a long, sweeping tail that extends downwards and to the right.

Mr. Keriako Tobiko, CBS, SC

Cabinet Secretary

MINISTRY OF ENVIRONMENT AND FORESTRY

Remarks from the Principal Secretary



Water towers are important ecosystems that play critical roles in the maintenance of ecological processes. They ensure continuous supply and availability of ecosystem services that supporting livelihoods. Unfortunately, these ecosystems are faced with myriad threats and challenges such as encroachment, forest fires, over extraction of water tower resources, land degradation, and increasing growth of invasive species. These threats have led to adverse environmental impacts hence affecting socio-economic development

The Ministry is committed to supporting conservation activities aimed at enhancing the Water towers ecosystem health and resilience. The initiative to increase the forest cover to 10% by 2022 is one of the National Strategies that the Government is implementing. I therefore appeal to all the stakeholders to support the implementation of the proposed interventions noted in this report.

I take this opportunity to appreciate Kenya Water Towers Agency for the efforts in developing such an invaluable report.

A handwritten signature in blue ink, appearing to read 'Chris Kiptoo', with a stylized flourish at the end.

Dr. Chris Kiptoo, CBS

Principal Secretary

MINISTRY OF ENVIRONMENT AND FORESTRY

Foreword



Kenya Water Towers Agency is mandated to co-ordinate and oversee the protection, rehabilitation, conservation, and sustainable management of Water towers. The Agency conducts periodic assessments of water towers to determine their status as an approach to provide critical data required to inform decision making for conservation in line with its mandate.

Mwangea Hill Water Tower faces a myriad of threats. Encroachment has led to a significant decline in forest cover causing massive loss of biodiversity, drying of rivers and springs and reduced agricultural productivity. The community livelihood has therefore been adversely affected. Therefore, successful reclamation and restoration of this Water Tower lies on effective collaborations and partnerships among key stakeholders. A multi-stakeholder approach is thus of paramount importance. As part of the Agency's plan to restore Mwangea Hill Water Tower, we have developed an Ecosystem Management Plan (EMP) which has provided a clear roadmap for conserving this ecosystem. I call upon the County Government of Kilifi and other stakeholders for collaboration in implementing the recommendations made in this report.

I wish to appreciate the Government for its commitment in recovering and restoring our Water towers. I acknowledge the support from the parent Ministry and the KWTA Board of Directors as well as management for taking leadership in coordinating activities aimed at conserving our Water Towers.

A handwritten signature in blue ink, which appears to read "Julius M Malombe". The signature is stylized and written in a cursive-like font.

Dr. Julius M Malombe

Board Chairman

KENYA WATER TOWERS AGENCY

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

Preface



Mwangea Water Tower is located at Kilifi County in the coastal region. All the rivers and streams are seasonal and drain into two major rivers: Sabaki and Vitengeni which are part of the Athi basin and lies within the Galana and Goshi sub catchment. Accordingly, there are only two seasonal springs recorded and several earth dams that serve the community during the dry season. Mwangea hills is rich with biodiversity with high diversity and endemism for both flora and fauna. The main socio-economic activities are subsistence crop production, livestock keeping and fruit farming. The water tower serves a population of more than 50,000 people.

Despite its importance, the water tower faces numerous challenges which include lack of legal protection, habitat degradation and fragmentation, charcoal production, unsustainable quarrying of rocks, unsustainable exploitation of forest resources, unsustainable agriculture, declining respect for the value of traditional culture, knowledge and practices in conservation. These threats have resulted in human wildlife conflict, drying of rivers and springs as well as loss of biodiversity. The status report has presented a comprehensive analysis on land use and land cover, critical catchment areas, biodiversity, ecosystem services and community livelihoods. Further the report has identified threats and challenges facing the Mwangea hills water towers and proposed interventions for restoration of its ecological integrity. In order to reverse this, we are calling upon stakeholders to partner with KWTA in conservation efforts.

Lastly, Let me acknowledge the support of the KWTA Board of Directors under the leadership of Dr Julius Malombe. I also appreciate the efforts of KWTA staff and Management and specifically that of the team at the Directorate of Ecosystem Research, Planning and Audit for their hard work that culminated in the production of this status report.

Prof. Julius G Tanui, PhD, EBS

Ag. Chief Executive Officer
KENYA WATER TOWERS AGENCY

Executive Summary

This status report gives detailed information on the status of Mwangea Hill Water Tower in Kilifi County. It covers on the status of hydrology and land cover and land use changes between 1990 and 2019. It also highlights on biodiversity, socio-economic and livelihood conditions of people living in the Water Tower. It further provides threats and challenges the ecosystem faces and proposed intervention to reverse these negative trends.

Mwangea Hill Water Tower is one of the coastal ecosystems covering 24,684 ha. It lies within the Galana and Goshi sub catchment which are part of the Athi basin. All the rivers and streams are seasonal draining in two major rivers: Sabaki and Vitengeni. There are only two seasonal springs recorded and several earth dams that serve the community during the dry season, although for a short period of time. The local community mainly relies on piped water for domestic use. This is supplied by Baricho Water Works.

The Water Tower has undergone significant changes in the past years. It was globally recognized as an area of great biological importance due to its diversity and high levels of endemism for both flora and fauna. However, due to high levels of degradation, the Water Tower has lost a large portion of its diversity. This has further impacted on its ability to provide essential ecosystem services. However, there are small portions of indigenous forest designated as sacred (Kayas).

Mwangea Hill forest is registered as a Trust Land under the County Government of Kilifi. The lack of legal protection has led to uncontrolled and over-exploitation of its resources. These include over-harvesting of trees for timber, charcoal production and encroachment for agriculture and settlement. As a result, a number of negative impacts have been witnessed including loss of biodiversity, reduced agricultural productivity, reduced water quantity and quality, increasing soil erosion and drying up of water sources mainly rivers and springs.

To curb these negative impacts and ensure conservation of the Water Tower, there is urgent need for its reclamation and rehabilitation. Therefore, an estimated budget of KES 542 million is provided to support proposed interventions as listed.

- 1. Reclamation and restoration of the Water Tower:** This will help address land ownership issues, encroachment and reverse degradation. This should be followed by gazettelement as a water tower.
- 2. Implementation of Ecosystem Conservation Plan:** For coordinated conservation and sustainable management of the Water Tower.
- 3. Removal of eucalyptus trees in farmlands** and discouragement of its growth as an on-farm tree species and promote growth of *Melia Volkensii* which does well in the area.
- 4. Promote and implement alternative community livelihoods:** To minimize pressure on water tower resources and alleviate poverty such as butterfly farming and bee keeping.
- 5. Creation of Environmental awareness** on the on the significance of water tower and the need to conserving it.

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Acronyms and Abbreviation

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	Meter
m³/s	Cubic Meter per Second
ML	Maximum Livelihood
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

A Water Tower is 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.

Water towers are multi-functional and provide significant ecosystem goods and services that are important for the livelihoods, hydrology 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 ecosystem services include provision of carbon sinks for climate change mitigation, water purification and storage for recharge of ground water and rivers, and being reservoirs of biodiversity for flora and fauna.

Water towers vary in size, shape, drainage patterns and features. There are five water towers largely recognized in Kenya namely; the Mau Forest complex, Mt. Kenya, the Aberdares, the Cherangany hills and Mt Elgon. In addition, 13 more water towers have been gazetted since 2012 (Fig. 1.1) and 70 more proposed by various stakeholders across the country (Table 1.1).

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

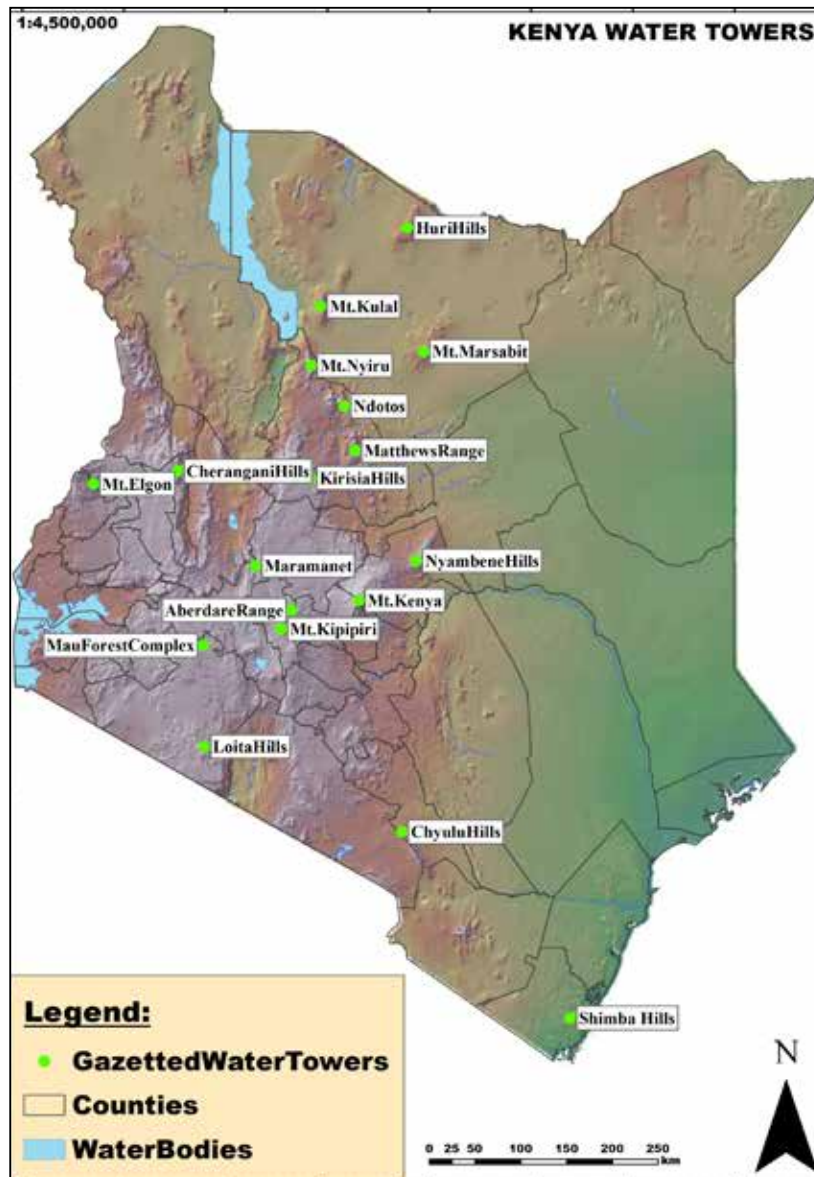


Figure 1.1: Gazetted Water Towers in Kenya

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 Tumutumumu hills Kiamacheru hills Nyara hills Nyeri hills	Kilifi County Mwangea hills	Baringo County Tugen hills	Kisii Nyangweta hills Sameta hills Taracha hills Nyachekei hills
Elgeyo Marakwet Elgeyo hills	Kirinyaga County Kerugoya hills	Makueni County Makuli hills Mbooni hills Nthangu hills Nzau 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	Kiambu Kikuyu escarpment	
Laikipia Mukogodo hill	Kajiado County Nguruman Escarpment	Mumoni/ Ngaikuyu hills Kyawea hills Mutha hills Nuu hills	Uasin Gishu Leseru Swamp	West Pokot. Chebuko/kamalegon Karasuk hills

Water towers influence all aspects of the economy including agriculture (irrigation), energy (hydropower), tourism (wildlife), urban development (water supply) and industry (water supply). Protection and conservation of these important ecosystems continues to face a number of challenges such as rapid population growth whose spiral effects include increased land fragmentation, encroachment on ecologically sensitive areas and over exploitation of declining natural resources within the water towers ecosystems. This results 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). 4

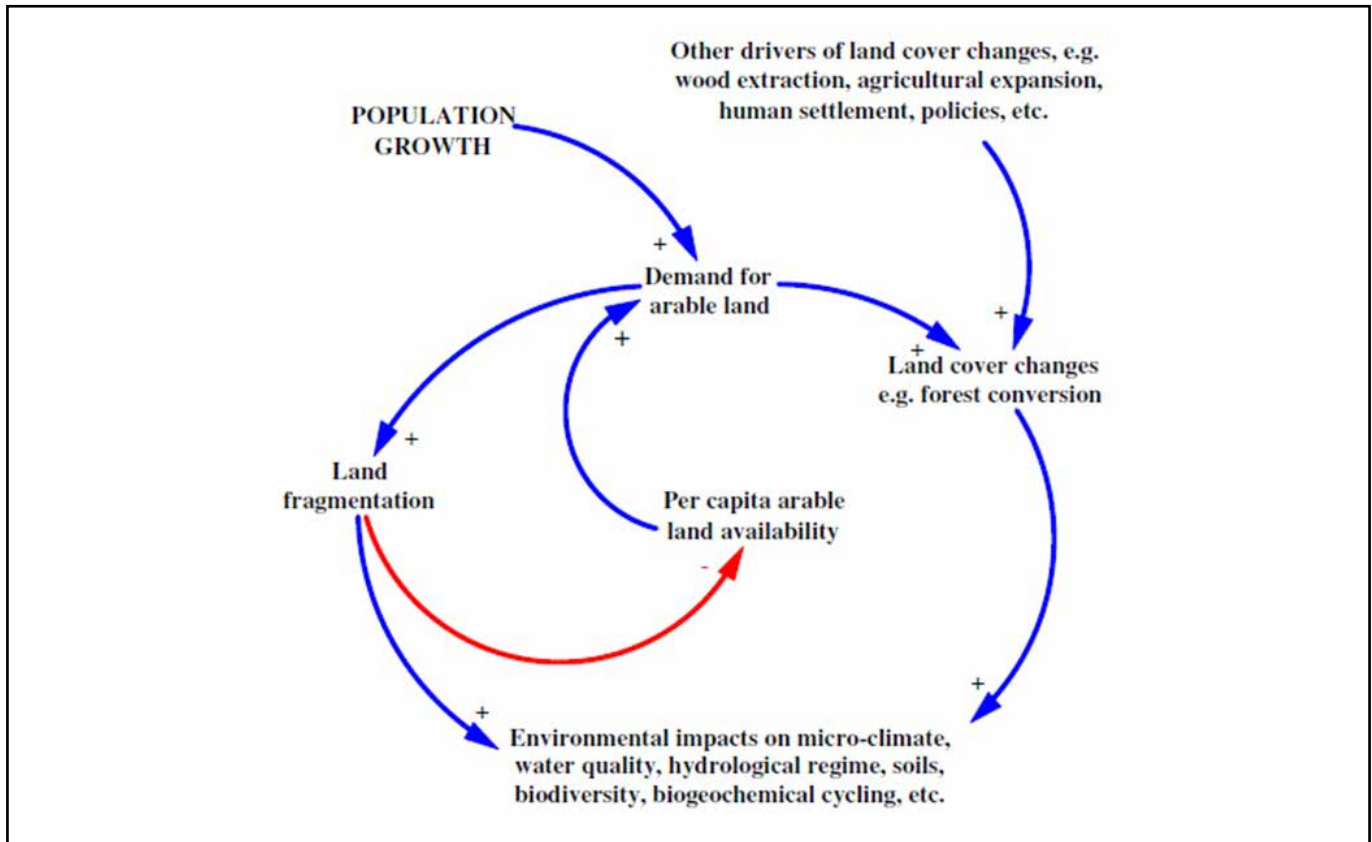


Figure 1.2: Causal loop diagram illustrating threats facing Water Towers (Were et al, (2013)

Note: The positive (+) sign denotes an increasing effect while the negative (-) sign denotes a decreasing effect)

1.1 Overview of Water Tower Status Reports

As it envisages being a global leader in Sustainable Management of Water Towers, KWTA commits to restore, conserve and manage the water towers and their ecosystems through coordination and conservation for Socio-economic development. To achieve this, there is need to provide accurate data and information as a tool to guide informed decision making in the conservation and management of the water towers. The information provides indications on the temporal and spatial changes in the Water Tower ecosystem while identifying the level of degradation and the causal factors. Further, it assists Government and non-Government stakeholders to identify priority measures for safeguarding the health and resilience of the ecosystems. The information collected also informs the alternative livelihood options to be implemented to alleviate pressure exerted on the water towers ecosystems.

1.1.1 Structure of the report:

- i. Introduction
- ii. Methodology of the study
- iii. Location, size and bio-physical attributes;
- iv. Biodiversity
- v. Hydrological attributes for the critical water catchment areas;
- vi. Land use and land cover changes between 1990 and 2018;
- vii. Socio-economic status and livelihoods of the surrounding communities;
- viii. Threats and challenges facing the Waters Tower
- ix. Profile of stakeholders and their roles in the sustainable management of the water towers and;
- x. Proposed measures for conservation and rehabilitation of the water towers.

1.2 Methodology

1.2.1 Socio-economic

Socio-economic data was collected to understand interaction between the local communities and the water towers. The data collected would also inform on alternative livelihood programs to be implemented.

The socio-economic data was collected through administration of questionnaires. The respondents were stakeholders drawn from state and non-state stakeholders within the Water Tower. Focused group discussions were also held at the location level to obtain data at community level

The population density map was generated based on 2009 demographic data. Actual densities were computed using ArcGIS and displayed as choropleth map at sub location level.

1.2.2 Land Cover and Land Use Assessment

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 1.4). 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.

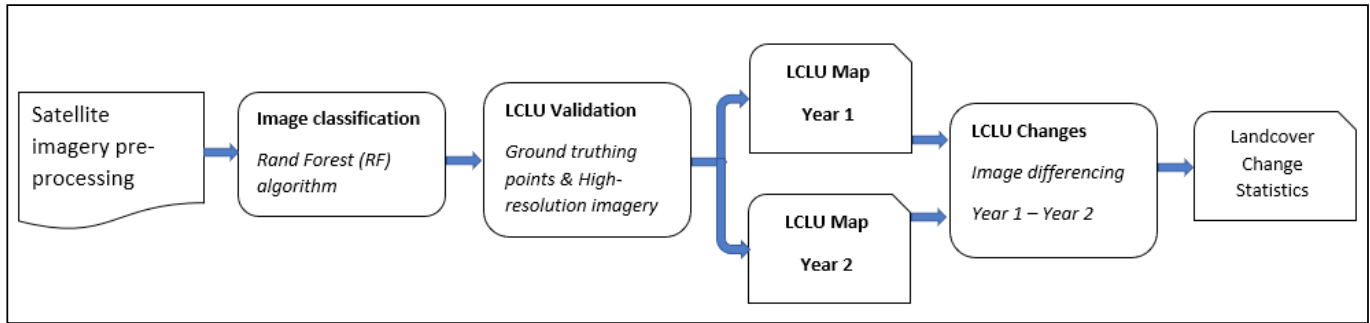


Figure 1.4: Process of mapping land cover and land use in the water tower

1.2.3 Assessment 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.

***“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***

Key Attributes

- Mwangea Hill is located in Kilifi County and traverses five locations namely Langobaya, Malanga, Mwahera, Chakama and Vitengeni.
- Traditionally this hill is believed to have been the first resting- place of the Mijikenda as they traversed the area from Shingwaya their ancestral origin
- Mwangea Hill is an 'island' in the hinterland of Kilifi County overlooking Tsavo East National Park.
- It has two summits, the higher, Mwangea MikobaChenda, is separated by a shallow valley from the lower Mwahera Sita.
- It is located on the Latitude 03° 15' S - 03° 25' S; and longitude 39° 43' E - 39° 72' E (Fig. 9). The forest covers an area of 3500 ha.

Key Threats and Challenges

- Encroachment for agriculture and settlement
- Charcoal Production
- Unsustainable agricultural practices on the slopes of the Water Tower
- Lack of legal protection
- Human-Wildlife conflict
- Forest fires
- Mining

Proposed Interventions

- Reclamation and rehabilitation of the Water Tower
- Development and implementation of Ecosystem Management Plan
- Provision of alternative community livelihoods
- Promote agroforestry options
- Creation of environmental awareness



A water pan in Mwangea Hill Water Tower © KWTa 2020

2.0 Background information

Mwangea Hill Water Tower is one of the coastal hill forests in the hinterland of Kilifi County overlooking Tsavo East National Park. It has two summits, the higher, Mwangea Mikoba Chenda, is separated by a shallow valley from the lower Mwahera Sita. The valley is as a result of a fault line running East West in the mazeras sandstone of which both hills are included.

Traditionally this hill is believed to have been the first resting- place of the Mijikenda as they traversed the area from Shingwaya their ancestral origin (Rrobertson,S and W. Luke, 1993).

In 1956 cultivation was allowed but only on the flat areas. Since then more areas of the forest have been opened and coconut and citrus trees planted. It is thought that some of the remaining pockets of rich summit forest may have been regarded as sacred or shelters a shrine and therefore may have been conserved by the local tradition.

2.1 Geographical Location

Mwangea Hill Water Tower is registered as a trust land under the Trust Land Act. It is located in Kilifi County cutting across five locations namely Langobaya, Malanga, Mwahera, Chakama and Vitengeni. It is located on Latitude 3.25694 and longitude 39.73666 (Fig. 2.1). The Water Tower covers an area of 24, 684 ha.

“Life depends on water, the reservoir depends on you.”
From best slogans for save water awareness and scarcity

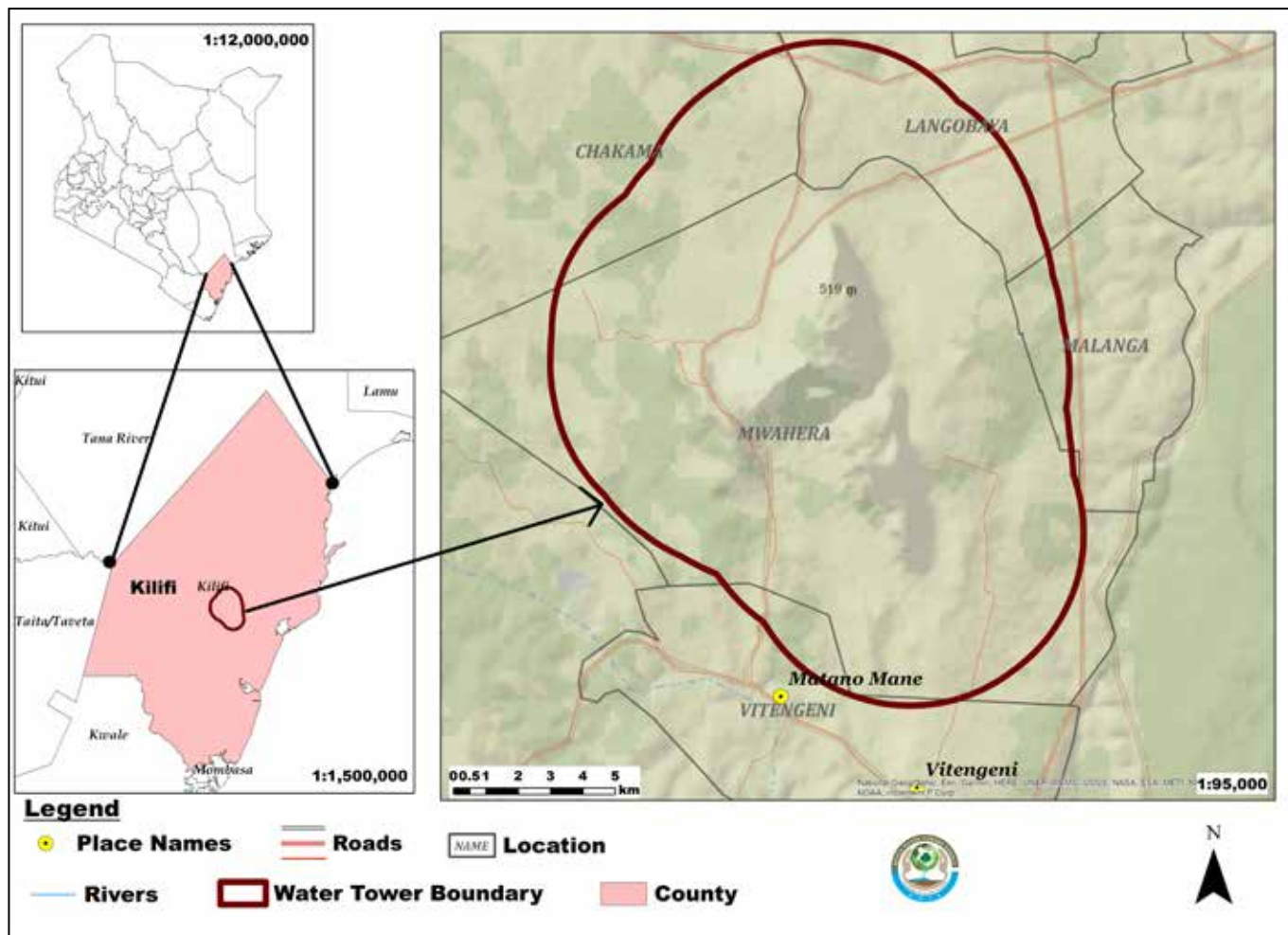


Figure 2.1: The Location of Mwang'ea Hill Water Tower in Kenya

2.2 Physical Description

2.2.1 Topography, Geology and Soils

The estimate terrain elevation above sea level is 625 meters.

The higher Eastern part of the Mwangea Hill Water Tower with the flat plateau consist of red soils. The lower Eastern slopes of the hill consists of sandy soils derived from sandstone of mazeras formation. The Northern and western slopes, which are steep, consist of more rocky geology that can only support drier flora. Generally, these soils have a low fertility and poor physical qualities making agriculture unreliable.

2.2.2 Climate

Rainfall and Temperature

The average annual rainfall for Mwangea Hill Water Tower is 300mm.

The annual temperature ranges between 30°C and 34°C. Kilifi County experiences relatively low wind speeds ranging between 4.8 km/hr and 12 Km/hr (Kilifi County CIDP, 2013).

2.3 Hydrology

The Water Tower lies within the Galana and Goshi sub catchment which are part of the Athi basin. All the rivers and streams are seasonal; filling and flowing only during the rain season. These include Katangani, Kazi ya Kawimbi, Kwamunga, Kwalango, Midugani, Kabuuni Mwahera, Kadzitsoni and Kwadadu (Fig. 2.2). These rivers and streams flow to Gosh/ Vitengeni river to the South and Galana/ Sabaki to the North of the Water Tower.

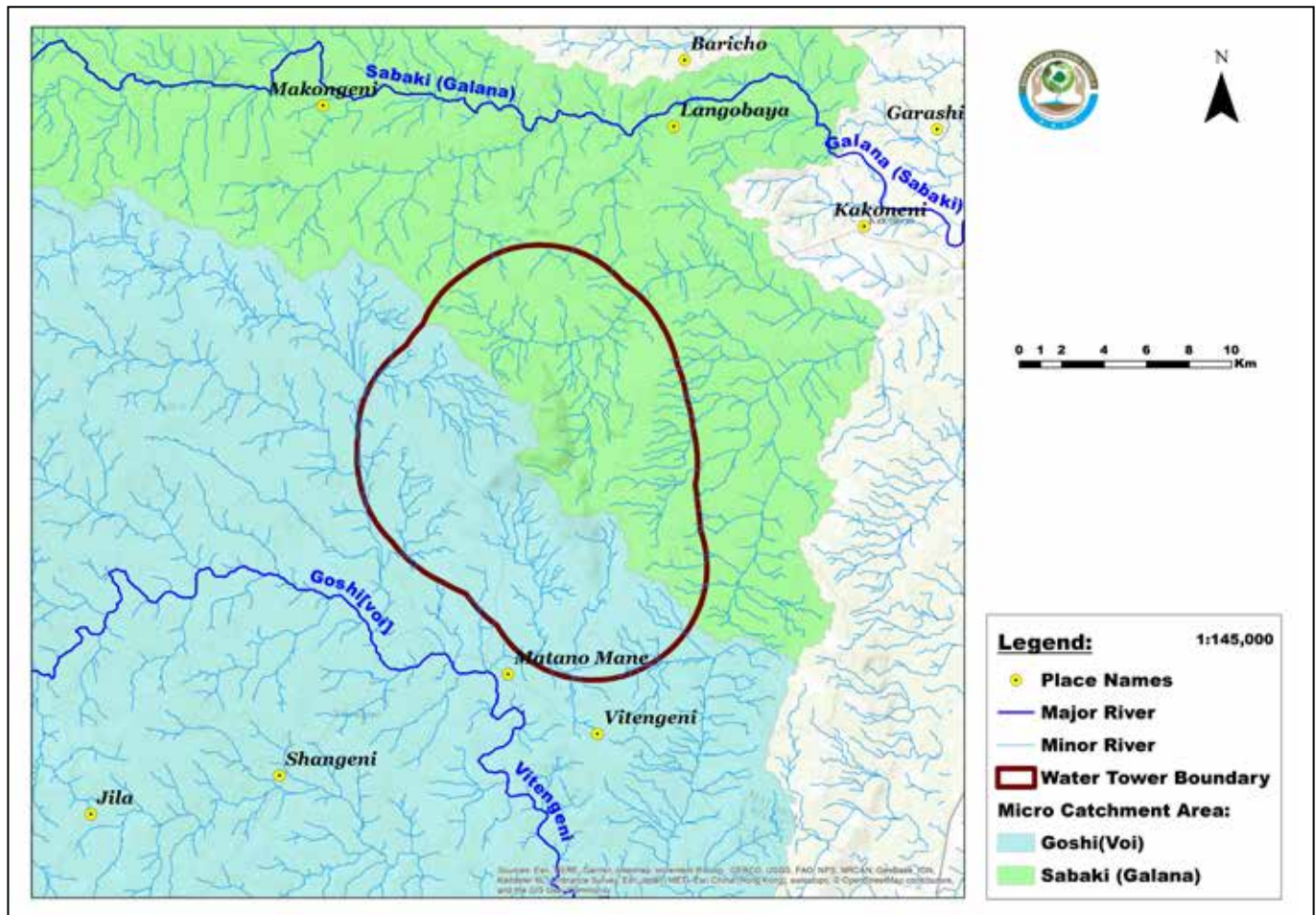


Figure 2.2: Drainage pattern in Mwangea Hill Water Tower

The Water Tower has only two seasonal springs; Kadzitsoni and Kwashindo both located in Mwahera location. Degradation that occurred in the ecosystem over time as a result of encroachment for settlement and agricultural activities caused most of the springs that once existed to dry up.

Other water sources are earthen dams which include: Kwa kijego, Kwa mwaiha, Kwa mkamba, Dangarani, Kwa katuku, Kisiwani, Kwa kamba, Kwa dadu, Kwa maitha, Kwa kacheku, Kwa mwalewa, Kwa mumba pala, Ziarakuruma, Bilakule, Kaziweni, Kwa mwambire, Kaziweni, Mwahera.



A water pan in Mwangea Hill Water Tower © KWTa 2020

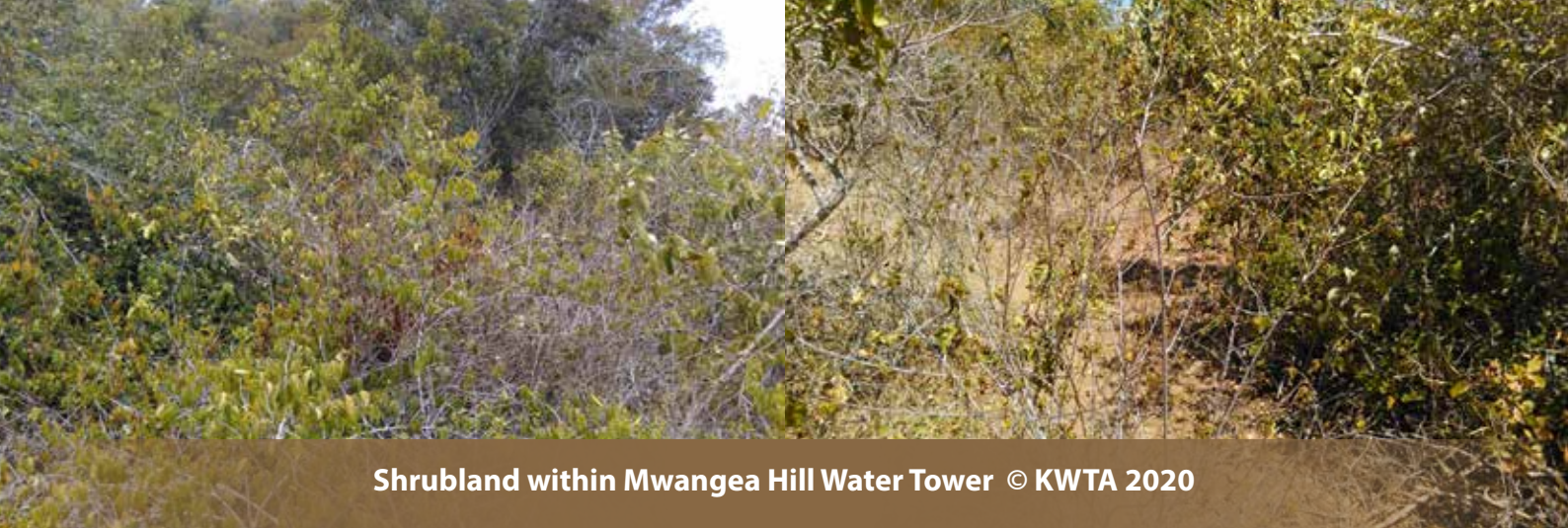
There is a water pipeline at the foot of the hill where the community fetch water at a cost of Kshs. 20 per 20 litres. This water is supplied by the Baricho water works project which is under the Kilifi-Mariakani Water and Sewerage Company (KIMAWASCO). The water is tapped from River Sabaki.

2.4 Biodiversity

East Africa's coastal forests like Mwangea Hill are globally recognized as areas of great biological importance due to their diversity and high levels of endemism for both flora and fauna. (WWF Global 2000, Conservation International Global Biodiversity Hotspots, 2004). However, due to degradation, the Water Tower has lost a large portion of its diversity.

2.4.1 Flora

The forest at the hill top of the Water Tower was extremely rich and diverse (Robertson & Luke, 1993). It contained among others rare species such as *Isolona cauliflora*, *Toussantia Orientalis*, *Synsepalum Kassneri*, *Erythrococca Pubescens*, *Petalodiscus Fadenii*, *Dichapetalum Fadenii* and *Macphersonia Gracilis*.



Shrubland within Mwangea Hill Water Tower © KWTa 2020

Much of this has been cleared for farming. The sandy lower Eastern slopes of the hill has *Brachystegia* woodlands grading upwards into a *Julbernardia* transitional zone. Other tree species include *Cleistanthus spp*, *Celtis mildbraedii*, *Pseudobersama mossambicensis*, *Manilkara discolor*, *Combretum schumannii*, *Brachylaena huillensis* and *Fernandoamagnifica*.

The Northern and Western slopes are steep and rocky and have dryland flora including *Combretum apiculatum* and the spectacular Cycad (*Encephalartos hildebrandtii*) and *Aloe volkensii*.

2.4.2 Fauna

Mwangea Hill Water Tower once considered a closed canopy coastal forest, has lost several wildlife species including Elephants, Lions, Hyenas, Cheetahs, Leopards, Giraffes, Zebras, Rhinos, birds like Owls, Ostrich and Clarke's weaver due to destruction of habitats, drying up of water sources, wild fires and poaching. Those still spotted within the Water Tower include few species of small mammals, snakes and insects. The mammals include squirrels, wild rats, monkeys, baboons, bats, dikdiks, tortoise, Golden elephant shrew and Warthogs. Snakes include python and cobra while insects include several species of bees and butterflies.

Habitat destruction due to encroachment has increased human-wildlife conflict.

2.5 Population

The Water Tower has a population of 38,590 persons consisting of 17,990 males and 20,600 females. Mwaheera and Vitengeni locations have the highest population of 14,896 and 9,699 respectively while Chakama and Langobaya locations have the lowest population of 2,338 and 2,290 respectively (Fig.2.3).

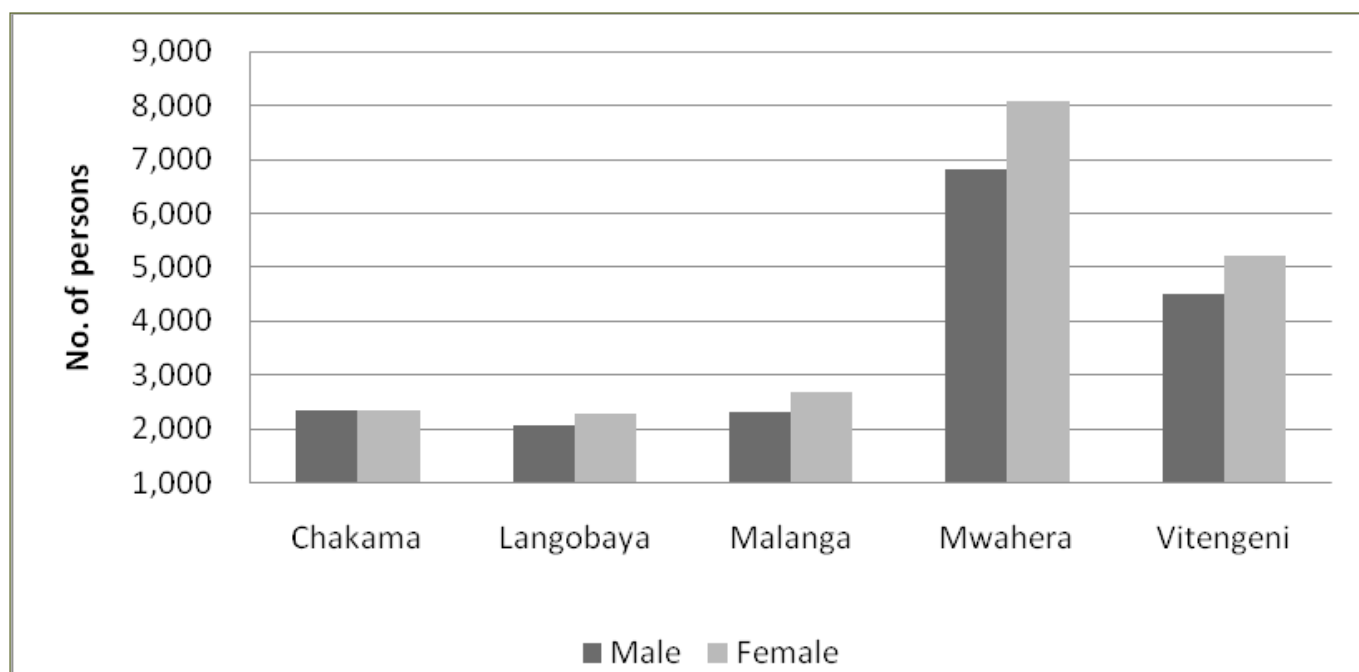


Figure 2.3: Population of Mwangea hill Water Tower

A larger area of Mwangea Hill Water Tower is found in Mwaheera location which has the highest population density (Fig. 2.4). The high population density in this location is a threat to the conservation of this Water Tower. It is therefore important to create awareness on its importance and the need to conserve and protect it for sustainable development.

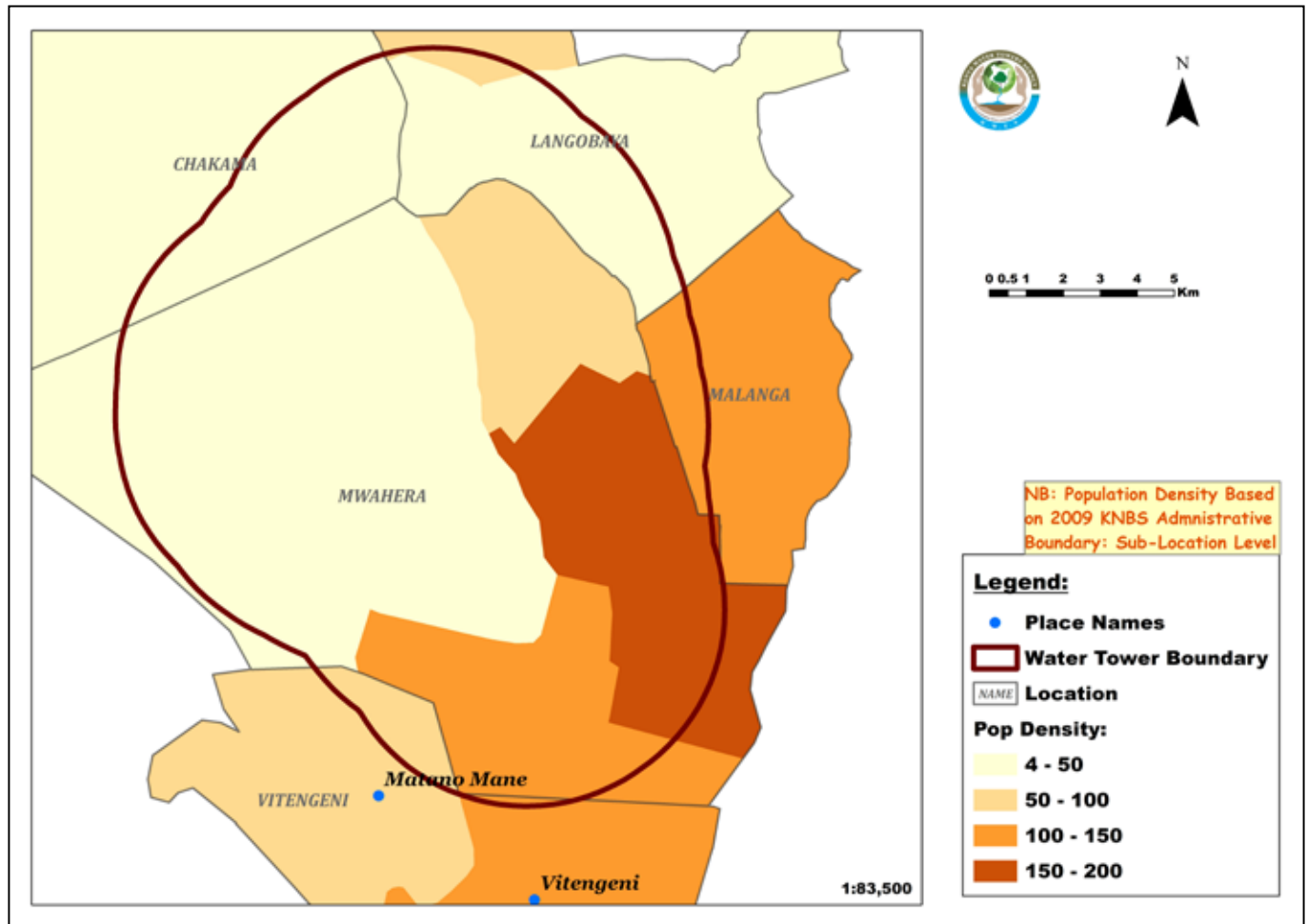


Figure 2.4: Population density in Mwangea Hill Water Tower

2.6 Ecosystem Services and Values

Mwangea Hill Water Tower offers several ecosystem goods and services to the community. The common exploited goods include timber, herbal medicine, charcoal and firewood and construction poles. The Water Tower is significant to the cultural and spiritual benefits of the community. The remaining patches of indigenous forest are considered Kayas and are protected for this sacred value. There is a Giriama legend, that a rock in Mwangea bears the imprint of divine foot making the hill a holy place.

In recent years, rampant over exploitation of resources has negatively affected the ability of the Water Tower to provide essential goods and services.

2.7 Socio-economic activities

The dominant community in Mwangea is the Giriama; one of the nine sub-tribes of the larger Mijikenda tribe/community. Agriculture is the main economic activity where coconut is the main cash crop whose products include oil extracts and palm wine. The palm tree fronds are used for roofing and as material for making baskets, mats, brooms and other weaved products. Other crops include maize, green grams, mangoes, pigeon peas, beans, watermelons, pumpkins, cassava, oranges, cashewnuts, cow peas, pepper, lemons and tangerines.

Livestock farming is also practised where they keep cattle, goat and sheep. This is common in Langombaya and Chakama locations. The community also practice bee keeping, fishing and poultry farming.

Agroforestry is practiced with an objective of supplementing family income. Komaza, a local NGO supports the plantation of *Eucalyptus* spp and *Melia Volkensii*.

2.8 Land Cover and Land Use classification

The major land cover in Mwangea Hill Water Tower is cropland, 9047 ha (37%) followed by grassland, 8748 ha (35%) and forest, 5723 ha (23%) and the least is wetland 247 ha, which represents 1% (Fig. 2.5). Cropland covers both annual and perennial crops. Annual crops consist of maize, cowpeas, beans, sorghum, vegetables and cassavas among others. Perennial crops include coconut, citrus and cashewnut trees.

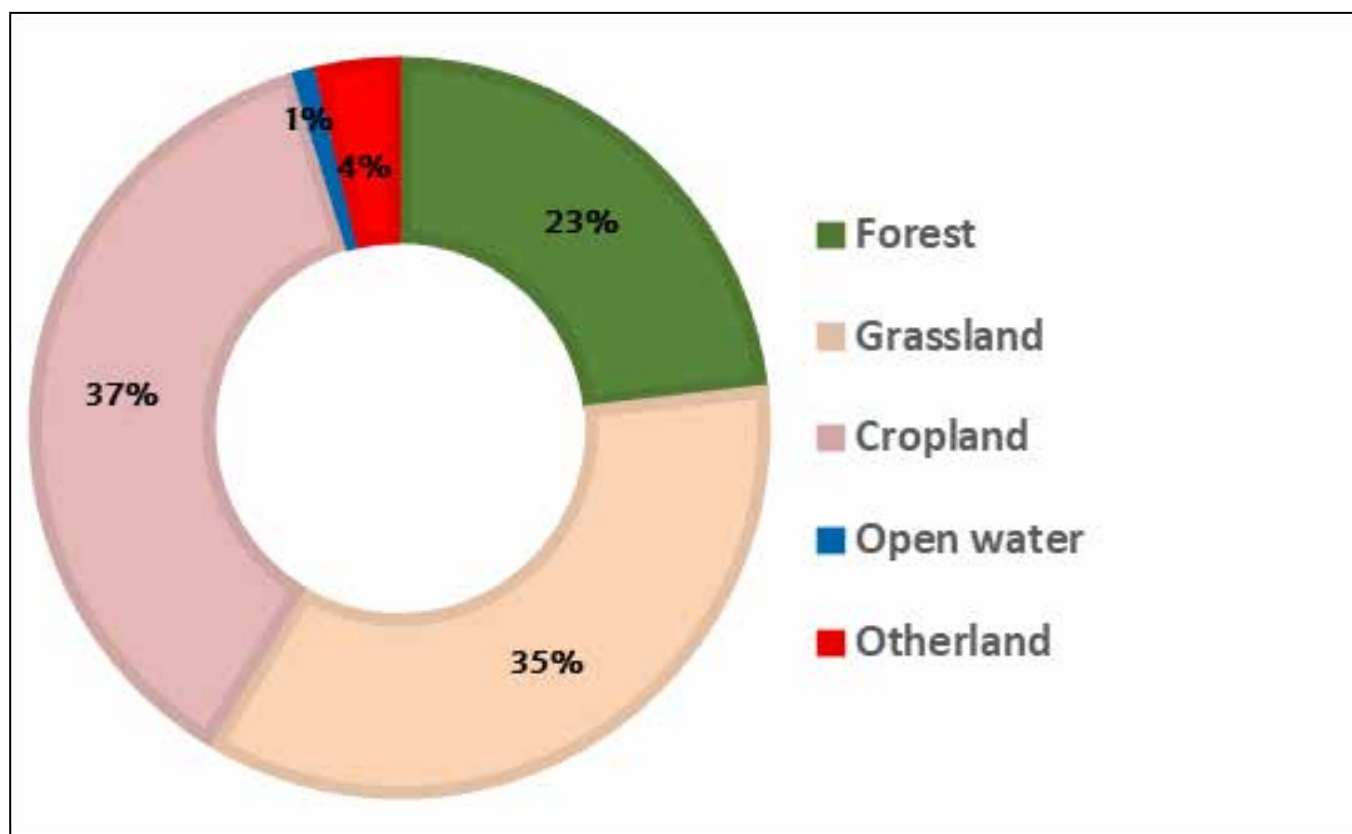


Figure 2.5: Land cover and Land use in Mwangea Hill Water Tower

2.9 Land cover and land use trend analysis

Over the period 1990 – 2018, the net LCLU changes varied from one LCLU class to another. All the classes with an exception of grasslands showed a net increase, with cropland recording the most increase (8309 ha). Grassland recorded the most decrease (-11570 ha) (Fig. 2.6).

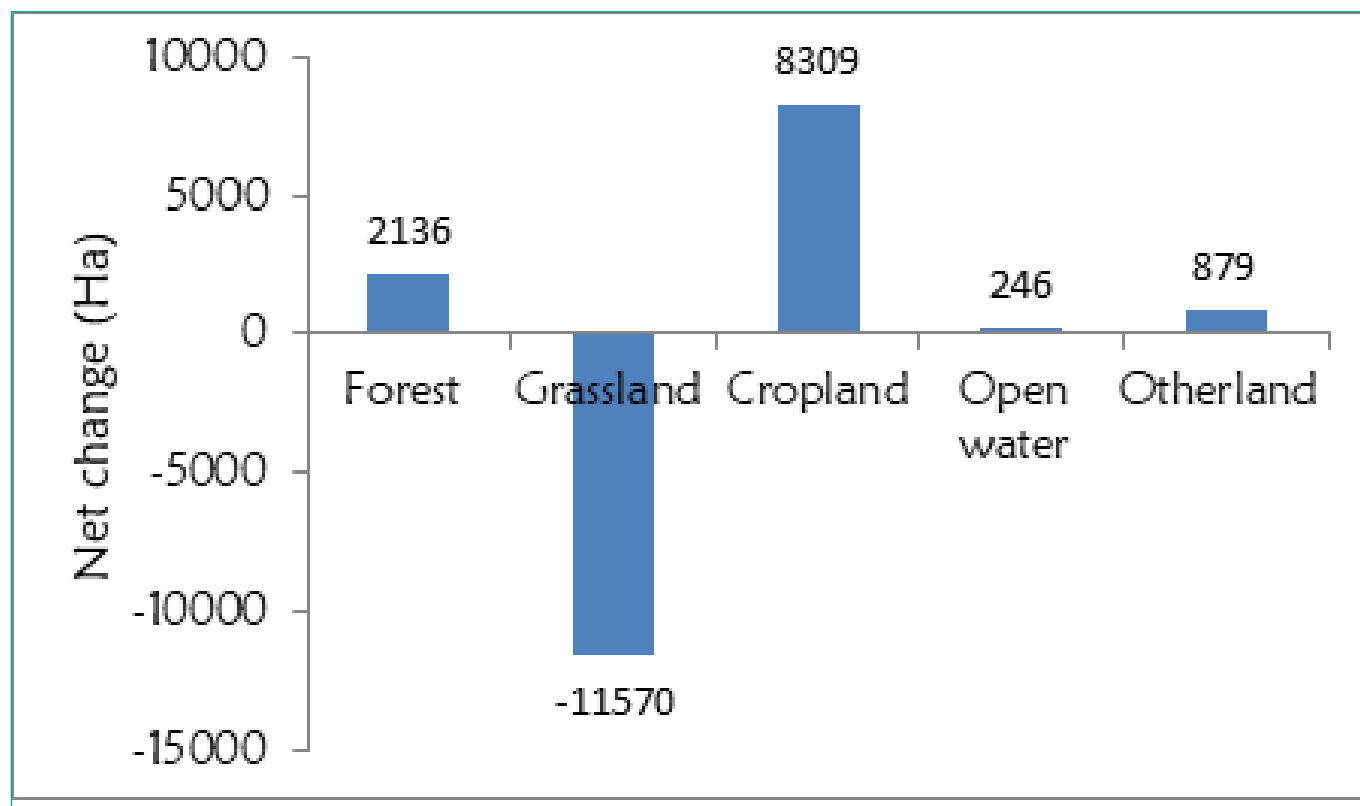


Figure 2.6 : Net changes in LCLU categories in Mwangea Hill from 1990 – 2019

The Land cover and land use trends indicate that forest has been on a downward trend since 1990 to 2014, recording cumulative loss of 2799 ha. Since then, conservation efforts have seen an increment of 4935 ha between 2014 and 2018 (Fig. 2.7). Grassland has been decreasing within the same period while cropland has been increasing (Fig. 2.7). This is an indication that most of the grasslands have been converted into croplands.

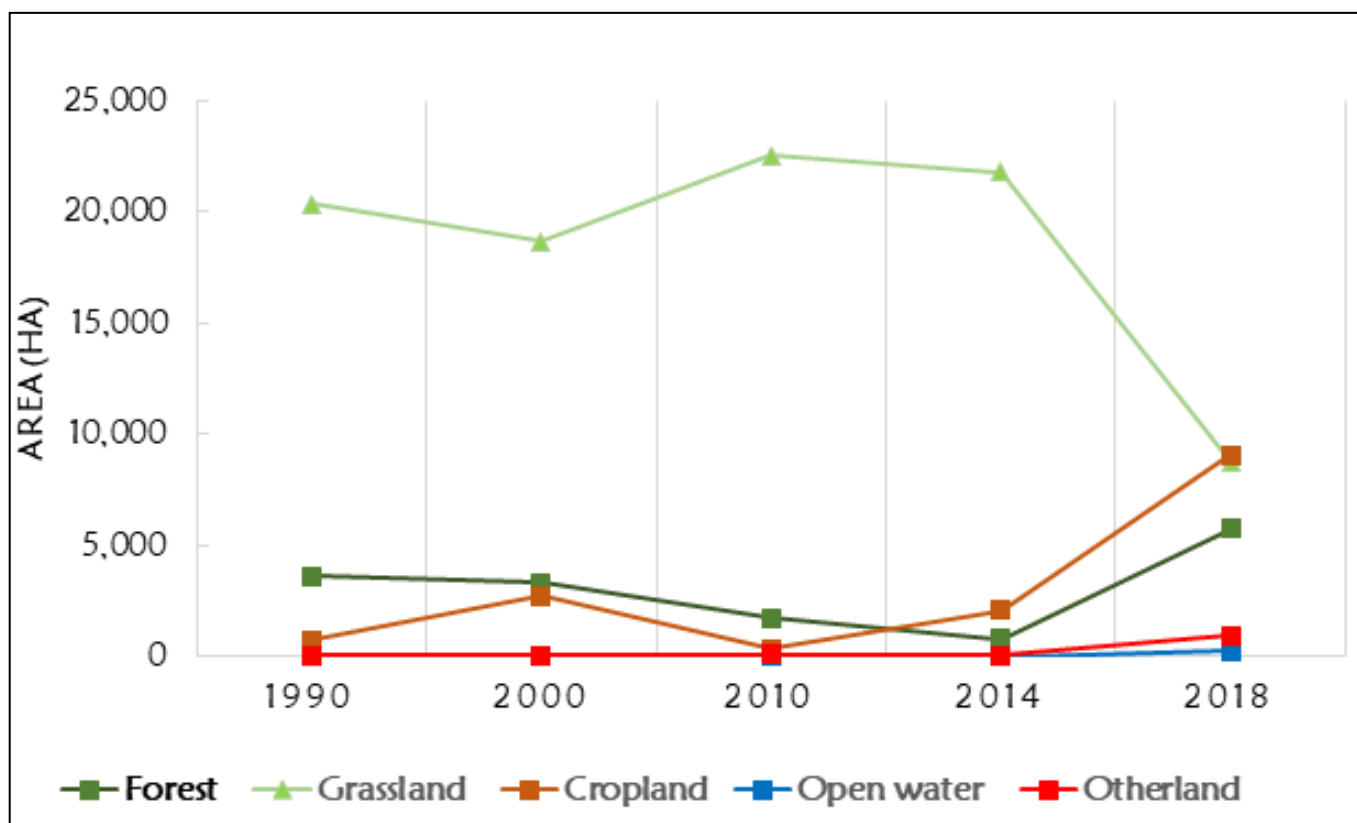


Figure 2.7: Land cover land use trend analysis in Mwangea Hill Water Tower

The figure below shows the gross LCLU classification in 1990, 2000, 2010 and 2018.

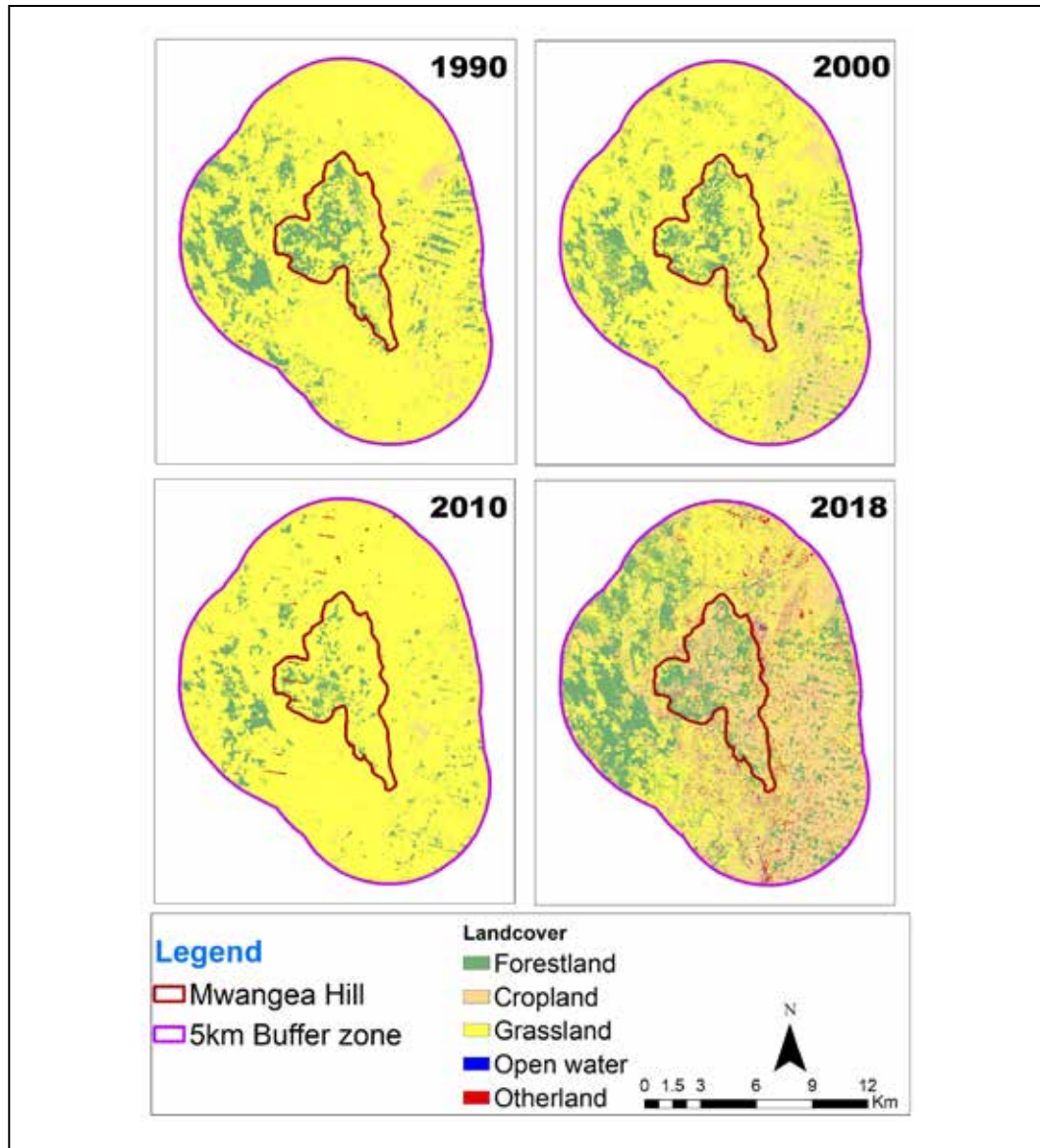


Figure 2.8: Land Cover Land Use classification map for Mwangea Hill Water Tower

2.10 Priority areas for conservation

Mwahera location faces the highest levels of degradation compared to other locations (Fig. 2.9 & 2.10). This location covers a major section of the Water Tower and it was noted that encroachment and forest destruction was rampant. The high level of degradation covers 2,934 ha, while the low and medium levels of degradation covers 5,465 ha and 16,277 ha respectively.

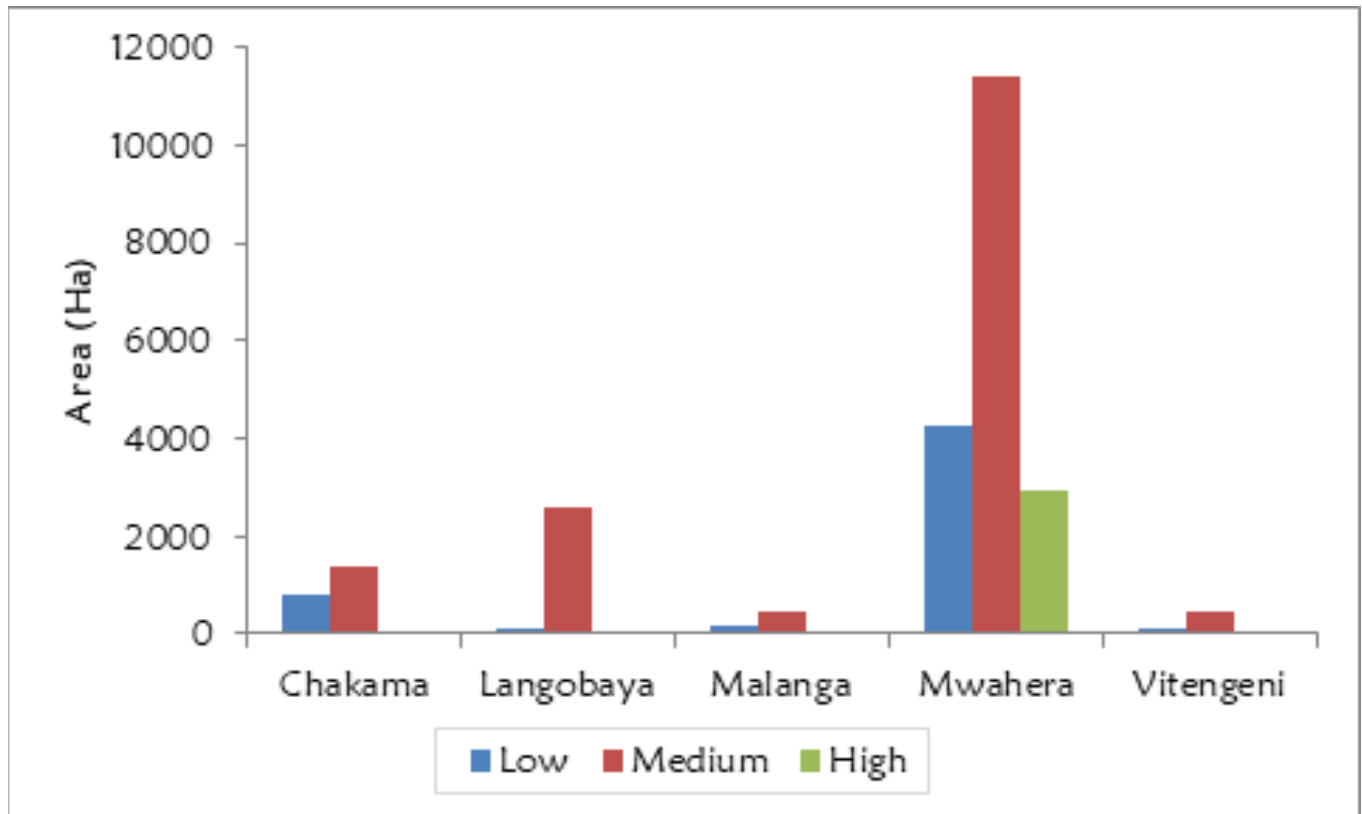


Figure 2.9: Levels of degradation in Mwangea Hill Water Tower

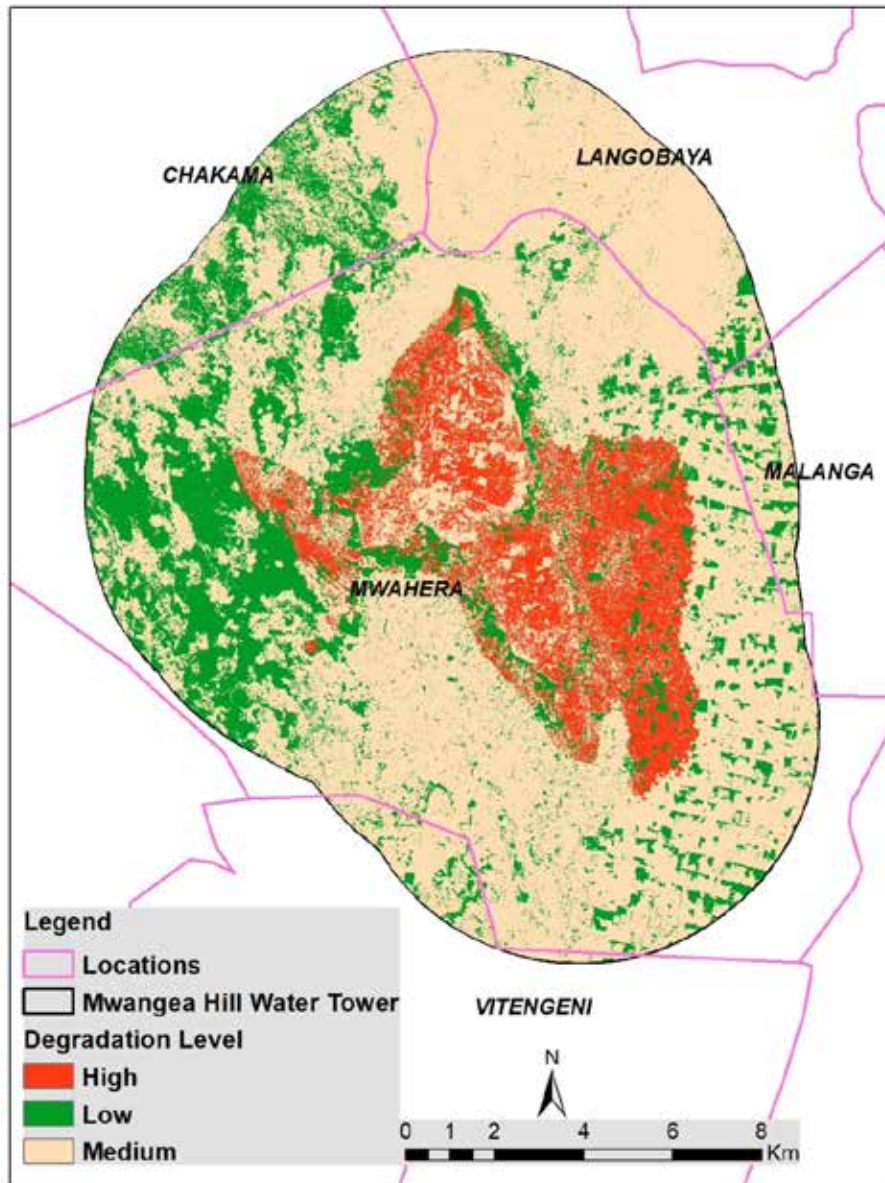


Figure 2.10: Map showing levels of degradation in Mwanagea Hill Water Tower



2.11 Stakeholder Profiling

There are several other stakeholders involved in conservation activities within the water tower. They include state, non-state and community. They play different roles as highlighted below:

Institution	Mandate
State stakeholders	
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 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.
3.	Kenya Wildlife Service To conserve and manage wildlife in Kenya, and to enforce related laws and regulations
4.	National Environment Management Authority 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.	County Government of Kilifi To work in collaboration with National Government in the protection and management of resources at the County level
6.	Kenya Forestry Research Institute Conduct forestry research and disseminate the research findings
7.	Water Resources Authority 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
8.	Coast Water Services Board To provide customers with innovatively developed maintained and managed water and sanitation infrastructure to achieve socio economic growth and environmental sustainability.
9.	National Museums of Kenya To collect, preserve, study, document and present Kenya's past and present cultural and natural heritage.

Institution	Mandate
Non-state stakeholders	
KOMAZA	Partners with rural farmers to plant woodlots that they manage collectively
Kilifi Charcoal Producers	Advocacy on sustainable charcoal production
A rocha Kenya	Conserve and restore threatened habitats and biodiversity through research, environmental action, advocacy and community empowerment.
Nature Kenya	Promotes study and conservation of nature in east Africa

2.11 Threats and challenges facing the Water Tower

1. Lack of legal protection

Mwangea Hill Water Tower is a trust land under the County Government of Kilifi. It lacks formal protection status and unclear boundary that has led to encroachment and the exploitation of resources with abandon. As a result, there is 'free access' to every member of the community and over time this has led to their over-exploitation and degradation.

2. Encroachment

Poverty and increasing population has led to increased demand for agricultural and settlement land, that has resulted to further encroachment into the summit of Mwangea hill. This has been aggravated by political interference. As more people settled in the area, the Government had to provide social amenities such as schools and hospitals. Mwangea primary school for instance, is located on top of the hill.

3. Charcoal Production

Mwangea hill has suffered major damage from illegal logging and clearing of the forest to provide fuel wood for Malindi, Kilifi and Mombasa.

The unsustainable open kilning coupled with weak law enforcement and increasing demand for charcoal contributes to continued depletion of forest resources.

The most affected areas include Mwangea location, Mikobachenda and Sita hill, Mwele, Kabuni, Midugani, Muchemudzo, Matsajeni and Kazandani.



4. Poor farming practices

Cultivation on the slopes and unsustainable farming practices such as slash and burn method of land clearing has increased soil erosion leading to development of gullies.

The common practice of slash and burn in the area reduces soil organic matter, exposing the soil surface hence aggravating soil erosion



5. Growing of exotic trees

The living in this water tower have replaced indigenous trees with fast growing exotic tree species mainly Eucalyptus species. There is an NGO called Komaza which has been supporting the growth of the Eucalyptus in this area. This species has adverse effects as it takes up a lot of water and suppresses growth of indigenous tree species hence reducing biodiversity.



6. Human-Wildlife conflict

Mwangea Hill shares wildlife corridors with Arabuko Sokoke forest which is home to several wildlife species.

Elephants, Lions, hyenas and baboons are the common problem animals leading to property destruction, loss of livestock through predation and human injuries and crop destruction..

8. Forest fires

Fire outbreaks are common within the Water Tower. This is attributed to the traditional slash and burn method of farming and charcoal burning. During slash and burn, winds spread the fire beyond farmland to nearby forested areas. Charcoal kilns when left unattended and with the effect of wind are also agents of forest fires. This has led to loss of key tree species and consequent change in forest cover.

9. Mining

The Water Tower is characterized by sandstone of Mazeras formation. The sandstone is harvested for sale and this earns income to support livelihoods of the local community. This extraction has caused landscape alteration, generation of unproductive wastelands resulting in formation of deep gullies and landslides.

“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

2.12 Proposed Interventions

1. Reclamation and restoration of the Water Tower

To address encroachment and reverse degradation, there is need to secure, reclaim, restore and gazette the Water Tower.

2. Ecosystem Conservation Plan

For coordinated conservation and sustainable management of the Water Tower, an Ecosystem Conservation Plan has been developed by KWTa. This provides a road map on the implementation of different conservation strategies for restoration of Mwangea Hill Water Tower needs to be implemented effectively.

3. Alternative community livelihoods

To minimize pressure on water tower resources and alleviate poverty, alternative livelihood interventions should be implemented.

4. Environmental awareness

To address low levels of environmental awareness it is important to establish community education programs on the significance of water tower conservation.





3.0 Proposed Implementation Plan

The matrix below provides a road map on implementation of the proposed interventions and the key stakeholders involved

No	Threats	Recommendation	Period (Years)	Budget (Ksh. Million)	Responsibility	Expected Outcome
1.	Low level of awareness on the importance of the Water Tower	Community sensitization, awareness creation and capacity building on conservation of the Water Tower	5	20	County Government of Kilifi, KWTA, Ministry of Interior and Coordination of National Government, Ministry of Education	Increased level of awareness and interest in conservation of the Water Tower by community members
		Promote environmental education in schools on conservation of water towers	5	20		
		Support environmental clubs in schools	5	10		
2.	Political interference	Awareness, Lobbying and advocacy	Continuous	12	County Government of Kilifi, KWTA, Ministry of Interior and Coordination of National Government	Political class sensitized of the need to restore the Water Tower

No	Threats	Recommendation	Period (Years)	Budget (Ksh. Million)	Responsibility	Expected Outcome
3.	Encroachment	Boundary realignment and demarcation	2	20	KFS, County Government	<ul style="list-style-type: none"> Increased forest cover Encroached areas reclaimed Improved monitoring of Water Tower
		Reclamation of encroached areas	5	40	KWTA, KFS, County Government and CFA's	
		Periodic aerial surveillance	Quarterly	20	KWS, KWTA, KFS	
4	Lack of legal protection	Gazettement of the Water Tower	1	15	KWTA, County Government of Kilifi, National Land Commission, Survey of Kenya	Improved protection status of the Water Tower
5	Habitat degradation and fragmentation	Undertake Ecosystem restoration through tree planting	5	50	County Government of Kilifi, KWTA, KFS, KFS, and NGO's	<ul style="list-style-type: none"> Restored water towers ecosystem Ecosystem Management Plan developed Soil stabilized
		Implement Ecosystem management plan	2	15		
		Gulley rehabilitation	4	30	County Government	
6	Charcoal production	Facilitate access to affordable and clean energy alternatives such as briquettes and energy saving jikos	4	40	County Government, KFS, KWTA, NGO's Community groups	<ul style="list-style-type: none"> Reduced dependence of charcoal as source of livelihoods charcoal production Adoption of alternative energy sources
		Enforcement of existing charcoal rules	3	10	KFS	

No	Threats	Recommendation	Period (Years)	Budget (Ksh. Million)	Responsibility	Expected Outcome
7	Unsustainable Quarrying of rocks	Develop quarrying guidelines	2	8	County Government, Community based groups	Sustainable management of quarrying sites
		Awareness and enforcement of regulations guiding quarrying	2	22		
8	Unsustainable exploitation of forest resources	Reduce pressure on forest-Planting of useful trees, promote use of stabilized building blocks	5	30	County, KWTA, KFS, KWS, KE-FRI, NGO's	Increased forest cover
		Develop sustainable alternative livelihoods	5	60	KWTA	
9	Poor agricultural practices	Awareness creation/sensitization	5	20	Ministry of Agriculture, NGO's, CFA's Department of planning	Adoption of sustainable agricultural production methods
		Implementation of land use policies	3	10		
		Promotion of sustainable land management practices (SLM)	5 years	20		
10	Eroded cultural values, indigenous knowledge and practices	Awareness creation and exchange visits	5 year	40	National Museums of Kenya and County Government, Nature Kenya	Improved adoption of culture
11	Human – Wildlife conflict	Community awareness	5 years	30	KWS, County Government	Reduced human-wildlife conflicts
Total				542		



4.0 Conclusion and Recommendation

Mwangea Hill has lost major part of its ecosystem health and resilience as a result of continued degradation which is majorly human induced. There is therefore urgent need to reclaim this Water Tower before any restoration work can begin. The County Government of Kilifi should ensure that there is strict enforcement of trust land policies. A multi stakeholder approach should be employed involving the community in all the restoration programs highlighted in the implementation matrix above.



Forest cover cleared to create land for farming



Remaining forest patches in Mwangea hills



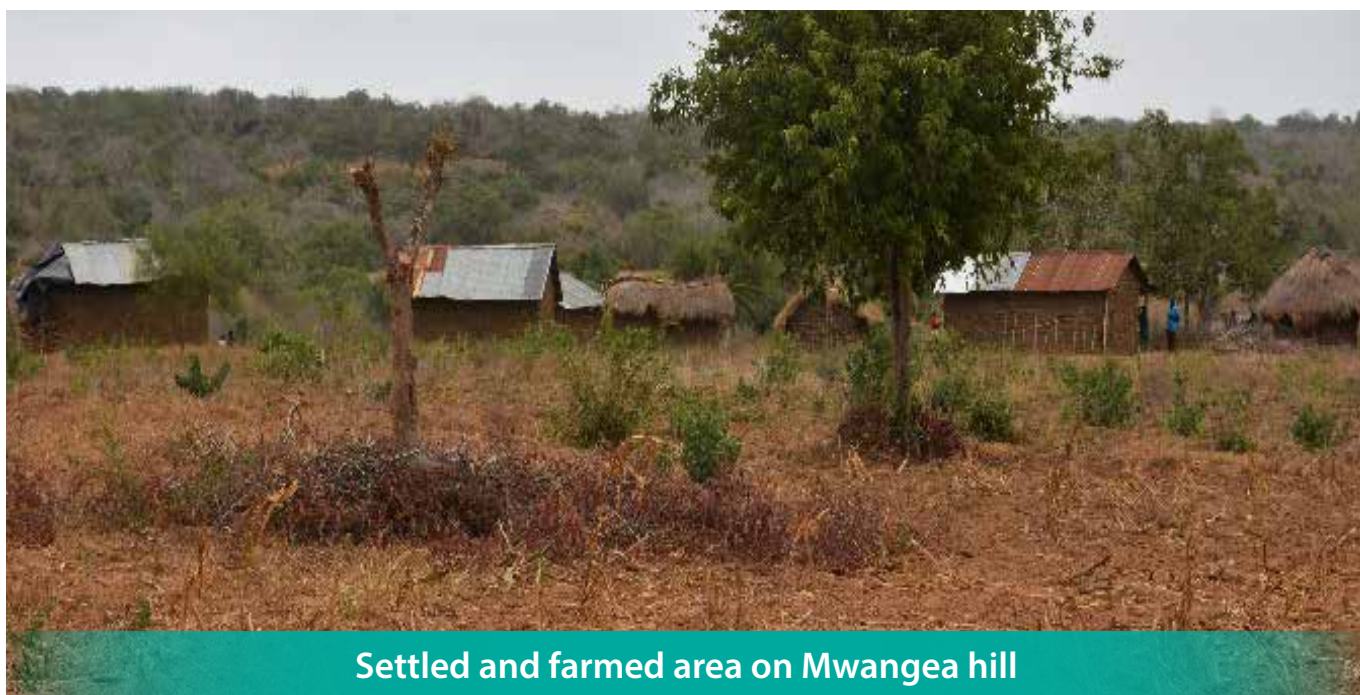
Charcoal production in the buffer zone



Charcoal kiln within the buffer zone



School build on encroached land



Settled and farmed area on Mwangea hill

Appendix 1: Preferred Tree Species for Rehabilitation and Their Uses

No.	Purpose	Common name	Scientific name	Local name
1.	Charcoal	Zebra wood/ Msasa	<i>Brachystegia spiciformis</i>	Mrihi
		Mfunda	<i>Cynometra webberi</i>	Mudodoma
		Dubard	<i>Manilkara sansibarensis</i>	Mng'ambo
		Dubard	<i>Manilkara sulcata</i>	Mtsedzi
		-	<i>Oldfieldia somalensis</i>	Mbirandu
		Milk berry	<i>Manilkara mochisia</i>	Munago
		-	-	Mukuha
		Spiny terminalia	<i>Terminalia spinosa</i>	Mwanga
		-	-	Mfungasanzu
2.	Firewood	-	<i>Julbernardia magnistipulata</i>	Mzahe
		Zebra wood/Msasa	<i>Brachystegia spiciformis</i>	Mrihi
		Mfunda	<i>Cynometra webberi</i>	Mudodoma
		Dubard	<i>Manilkara sansibarensis</i>	Mng'ambo
		Spiny terminalia	<i>Terminalia spinosa</i>	Mwanga
		Milk berry	<i>Manilkara mochisia</i>	Mnago
		-	<i>Oldfieldia somalensis</i>	Mbirandu
		-	-	Mukuha

No.	Purpose	Common name	Scientific name	Local name
3.	Building and construction	Hennings strychnos	<i>Strychno shenningsii</i>	Mbathe
		Dubard	<i>Manilkara sansibarensis</i>	Mng'ambo
				Mulutswa
		Mfunda	<i>Cynometra webberi</i>	Mudodoma
		-	-	Mtiri
		-	-	Mtoro
		Lowveld silver oak	<i>Brachylaena huillensis</i>	Muhuhu
		-	<i>Julbernardiamagnistipulata</i>	Mzahe
		Dubard	<i>Manilkara sulcata</i>	Mtsedzi
	Russet bushwillow	<i>Combretum hereroense</i>	Mchirangombe	
4.	Timber	Zebra wood	<i>Brachystegia spiciformis</i>	Mrihi
		Dubard	<i>Manilkara sansibarensis</i>	Mng'ambo
		Lowveld silver oak	<i>Brachylaena huillensis</i>	Muhuhu
		Neem tree	<i>Azadirachta indica</i>	Mkilifi
		False marula	<i>Lannea schweinfurthii</i>	Mnyumbu
		Coconut palm	<i>Cocos nucifera</i>	Mnazi
		-	-	Mpendabure
		Pod mahogany	<i>Afzelia quanzensis</i>	Mwamba
5.	Herbal medicine	Yellow heads	<i>Hoslundia opposita</i>	Mtserere
		-	-	Msazakobe
				Muhirihi
		Neem	<i>Azadirachta indica</i>	Mwarubaini
			<i>Oldfieldia somalnensis</i>	Mbirandu
		Pod mahogany	<i>Afzelia quanzensis</i>	Mbambakofi
		Goose berry	<i>Dovyalis abyssinica</i>	Mdungu
		Aloe vera	<i>Aloe barbadensis</i>	Kitozi
	-	<i>Turraea robusta</i>	Mwalaga kuku	

No.	Purpose	Common name	Scientific name	Local name
6.	Others i.e. used as a poison for fish	-	<i>Syandenum pereskiifolium</i>	Mtupa
7.	For arrow poisoning and bird traps	-	-	Chaa
8.	For weaving 'uteo'	Cycads	<i>Encephalartos hildebrandtii</i>	Kitsapu

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