Rising Water Levels in Kenya's Rift Valley Lakes,
Turkwel Gorge Dam and Lake Victoria

REPUBLIC OF KENYA

UNDP

Rising Water Levels in Kenya’s Rift Valley Lakes,

Turkwel Gorge Dam and Lake Victoria

A SCOPING REPORT

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Foreword

The rising water levels of Lake Victoria and the Rift Valley Lakes, along with the Turkwel Gorge Dam raised concerns that prompted the Cabinet through the advice of the National Security Advisory Committee (NSAC) to direct the Ministry of Environment and Forestry to set up a Multi-Agency Technical Team to embark on a scoping mission of the affected water bodies. The objective was to try and establish the causes, the socio economic impacts and to recommend interventions for cushioning the affected communities.

It is to be appreciated that the rising lake water levels and accompanying flooding had stirred panic and anxiety among the surrounding communities where the floodwaters have left trails of destruction and rendering hundreds of families' homeless. There has been consequential loss of crops, farmland and pasture. The wildlife was not spared either as the loss of grazing land drove them to higher grounds where displaced families had also sought refuge and hence leading to human-wildlife conflict.

Following the advisory by NSAC and the Cabinet directive, the Ministry of Environment and Forestry constituted the Multi-Agency Technical Team to interrogate the extent of the impacts occasioned by the rising lake water levels through a field scoping activity. The Ministry brought on board partners that included United Nations Development Programme (UNDP), United States Agency for International Development (USAID) and United Nations Educational, Science and Cultural Organization (UNESCO) who supported the formulation of roadmap for the lakes scoping mission and also provided the much-needed financial support. The comprehensive scoping mission covered all the affected lakes and areas of Lake Victoria and the Rift Valley Lakes of Turkana, Logipi, Baringo, Bogoria, Nakuru, Solai, Elmenteita, Naivasha, Ol-Bolossat, Magadi, including Turkwel Gorge Dam and the flood plains of Ewaso Ngiro South. The result has been this detailed report which, critically, also captures the voices of the affected stakeholders and providing the necessary evidence on the psycho-social impacts on the communities. It also presents a way forward on short, medium and long-term strategies that can assist in the management of the impact. The recommendations will further guide formulation of appropriate measures in order to mitigate the impacts, ultimately cushion the affected communities and plan recovery of the lost biodiversity.

It is my hope that our development partners will continue to support the government in developing a comprehensive recovery marshal plan that will help the affected communities to endure the phenomenon and cope with it in a sustainable way. The Ministry is therefore fully committed to partner with stakeholders in the formulation and implementation of practical and long-term solutions to this phenomenon. We therefore look forward to partnering with all the key stakeholders in designing an integrated programme that will respond to the rising water challenge while also strengthening the climate change adaptation measures.

Keriako Tobiko, CBS, SC,
Cabinet Secretary, Ministry of Environment and Forestry

Preface and Acknowledgements

The National Security Advisory Committee (NSAC) made a recommendation to the Ministry of Environment and Forestry (MoEF) to constitute a Multi-Agency Technical Committee to assess the socio-economic impacts and causes of the rising water levels within the Great Rift Valley Lakes, the Turkwel Gorge Dam and Lake Victoria. This followed the trend of the water level rise that has been witnessed since September 2010 and that significantly affected the areas in 2013 and again since 2019 to date. The Lakes level rise has led to the submergence of nearly all the riparian land and displacement of thousands of people. The entire infrastructure (roads, settlements, social amenities, grazing land, farmland, fish landing and processing facilities, electricity lines, water supply structures) and wildlife habitats have been destroyed leading to significant loss of livelihoods and biodiversity. There has been increased human wildlife conflicts occasioned by shrunk habitats and stress both on animals and humans.

The Ministry of Environment and Forestry took up the task and in collaboration with the United Nations Development Program (UNDP), constituted six (6) teams (Appendix 1) to undertake a scoping mission on the lakes and the Turkwel Gorge Dam from 21st October to 1st November 2020 as follows: (a) Lake Turkana, Turkwel Gorge Dam and Lake Logipi; (b) Lake Bogoria and Lake Baringo; (c) Lake Nakuru, Lake Elmenteita and Lake Solai; (d) Lake Naivasha and Lake Ol Bolossat; (e) Lake Magadi and Ewaso Ngiro South area and (f) Lake Victoria. The teams were tasked to assess and report on the status of the rising water levels and the allied socio-economic impacts with a view to making recommendations on required intervention measures. The report also captures the implications of the rising water levels on security, the ecological changes, previous record of changes in the lakes, the catchment area dynamics, the geological setting that control the flows into and out of the lakes, and possible litigation from the affected communities.

The abridged and more reader-friendly version of the main report from the Multi-Agency Team establishes the ground upon which policy decisions can be made on the physical planning direction and re-development of the affected areas. The results from the scoping mission reveal a complex interplay of hydro-meteorological factors, land use change dynamics as well as the geology and morphological setting of the lakes which have relatively influenced the current phenomenon. The report demonstrates the extent of destruction of human settlement and livelihoods, critical infrastructure such as buildings, roads, electricity and bridges and loss of farmlands and grazing lands. The exercise has produced a large compendium of data and information on the ten (10) lakes and their ecosystems. The Multi Agency Technical Team has also provided invaluable recommendations on short, medium and long-term interventions measures together with an implementation plan that will provide a road map on the expedite service delivery to the affected communities. Given the magnitude and the impact of rising lake water levels on livelihoods, the Government urgently requires bilateral and multilateral agencies to support the design and implementation of a comprehensive programme that would safeguard the people and nature by enhancing community and ecosystem resilience.

In compiling the reports, I wish to acknowledge the contributions and support of the following Ministries, State Departments and government institutions:

(i) Ministry of Interior and Coordination of National Government;

(ii) Ministry of Defence;

(iii) Ministry of Devolution and the ASAL;
(iv) Ministry of Tourism and Wildlife;
(v) Ministry of Health;
(vi) Ministry of Water Sanitation and Irrigation;
(vii) Ministry of Energy;
(viii) Ministry of Transport, Infrastructure, Housing and Urban Development and Public Works;
(ix) Ministry of Education, and;
(x) Ministry of Agriculture, Livestock, Fisheries and Cooperatives.

The other government institutions that were involved included the Water Resources Authority (WRA); Directorate of Resource Surveys and Remote Sensing (DRSRS); Kenya Electricity Generating Company PLC (KenGen PLC); Kenya Wildlife Services (KWS); the Climate Change Directorate (CCD); Kenya Forest Service (KFS), University of Nairobi (UoN) and Kenyatta University(KU). Others were the County Governments of the affected regions; the President's Delivery Unit; National Environment Tribunal; Kenya Meteorological Department, National Land Commission(NLC), National Disaster Operations Centre (NDOC), Council of Governors(COG), and the Office of the Government Spokesperson. We would also like to note and appreciate the Kenya Marine and Fisheries Research Institute (KEMFRI) who supported the much-needed navigation of Lake Turkana, and other areas.

The team was further supported by the Kenya Red Cross Society (KRCS); the United Nations Development Programme (UNDP) and the Stockholm Environment Institute (SEI). Here, I must state rather categorically, that the successful completion of the scoping mission and the production of the reports, is owed to the fruitful, collaborative partnership between UNDP and the Ministry of Environment and Forestry. We sincerely thank the UNDP Resident Representative for expeditiously providing the required technical and financial support that enabled us to undertake the task. In similar vein, we acknowledge the additional financial support that was availed by the USAID mission through its director, Mr Mark Meassick.

We particularly appreciate the cooperation and support offered by the County Governments of Baringo, Busia, Homa-Bay, Kajiado, Kisumu, Marsabit, Migori, Nakuru, Narok, Nyandarua, Siaya, Turkana, and West Pokot that were visited during the scoping mission. These County Governments warmly received the scoping mission teams, organized meetings, discussions, and the field visits, and also provided information and documentation; including reports of assessments they had undertaken in the past. The same depth of gratitude is due to the affected communities and institutions in the field most of whom came out to share their experiences and offered support.

Last, but not least, the overall leadership and coordination was provided by Mr Erick Akotsi, (Acting Environment Secretary) and Dr Pacifica Ogolla, (Director of the Climate Change Secretariat), Ministry of Environment and Forestry and Mr Geoffrey Omedo from UNDP.

Finally, we acknowledge the dedicated work of the various technical experts who worked at various stages to draft, and ultimately ensure the production of a high quality and readable report.

Dr Chris Kiptoo, CBS
Principal Secretary, Ministry of Environment and Forestry

A Word of Solidarity from UNDP

UNDP has a long and cherished history of collaboration and partnership with the people and the Government of Kenya. It is in this tradition that we are extremely delighted to have been at the forefront when the crisis of rising water levels in Kenya's Rift Valley, Turkwel Gorge dam and Lake Victoria emerged in the course of 2020/21 and to have partnered with the Ministry of Environment and Forestry who led a multi-agency task force to identify the underlying causes for this phenomenon and identify the multi-faceted impacts. To be sure, the very phenomenon of rising water levels that has led to the destruction of livelihoods and biodiversity is not new in Kenya. Since more than a decade ago, we have all been witness to heavy and unusual rainfall patterns or other extreme weather events whose impacts are serious and far reaching.

Globally, it has become almost axiomatic, that we are living in extremely unusual times, Climate Change and its associated disasters, are with us and it is no surprise that various manifestations of weather and climate extremes are being witnessed more frequently now.

As the UN agency charged with responsibility to work with governments world-wide in the developmental space, it has been our privilege and duty to have joined with the government of Kenya at a critical hour of need. It is my hope and that of the entire UNDP family, that this scoping report will go a long way in helping find long-term solutions, including adaptation and building resilience against the vulnerabilities that these changing climate and weather conditions are forcing upon us.

As the main report and this abridged version's titles readily suggests, the 'Scoping Report' is only a beginning, in perhaps, what might turn out to be a most complex and long-drawn journey of seeking solutions on a sustainable basis to this realty of our time. The impacts at the socio-economic level, legal, security and geological levels, just to mention a few of those covered in this report, are serious and likely to be with us for a long time. If the report can trigger actions and responses, including the mobilization of resources needed to address both the immediate and long-term needs, it will have served an extremely useful purpose. I would like to thank the United States Agency for International Development (USAID) for readily availing resources to UNDP to be able to provide flexible and catalytic support to undertake this initial assessment work.

Our support here has served to bring to the fore some of the core messages and recommendations outlined in our Human Development Report 2020 entitled "The Next Frontier: Human Development and the Anthropocene", which strongly advocated for striking a better balance between people and planet. As UNDP Kenya, we commit to continue walking with the Government and people of Kenya in the immediate and long term to ensure that the quest for sustainable livelihoods and mutual co-existence across ecosystems with the numerous emerging natural vulnerabilities, is in some ways managed and contained.

Walid Badawi
Resident Representative

Abbreviations and Acronyms

ASAL	Arid and Semi-Arid Lands
BMUs	Beach Management Units
CBO	Community Based Organization
CO_2	Carbon Dioxide
CRSPs	Climate Resilient County Spatial Plans
DEM	Digital Elevation Model
DO	Direct Observation
DRSRS	Directorate of Resource Surveys and Remote Sensing
EARs	East African Rift Valleys
ENSO	El-Nino Southern Oscillation
FGD	Focus Group Discussions
GIS	Geographical Information System
Ha	Hectares
IOD	Indian Ocean Dipole
ITCZ	Intertropical Convergence Zone
IWUA	Irrigation Water Users Association
KALRO	Kenya Agricultural Livestock Research Organization
KEFRI	Kenya Forest Research Institute
KenGen PLC	Kenya Electricity Generating Company PLC
KFS	Kenya Forest Service
KII	Key Informants Interviews
KMD	Kenya Meteorological Department
KMFRI	Kenya Marine and Fisheries Research Institute
KVDA	Kerio Valley Development Authority
KWS	Kenya Wildlife Services
KRCS	Kenya Red Cross Society

KWTA	Kenya Water Towers Agency
LBDA	Lake Basin Development Authority
LULC	Land Use & Land Cover
M asl	Meters above sea level
MEF	Ministry of Environment and Forestry
MW	Megawatts
NASA	National Aeronautics and Space Administration
NDOC	National Disaster Operations Centre
NEMA	National Environment Management Authority
NSAC	National Security Advisory Committee
SMEs	Small- Medium Enterprises
SRTM	Shuttle Radar Topography Mission
UNDP	United Nations Development Programme
USAID	United States Agency for International Development
WRA	Water Resources Authority
WRUA	Water Resources User Association

Executive Summary

The rising water levels of the Rift Valley Lakes, Turkwel Gorge Dam and Lake Victoria has been a major cause of concern to the country's socio-economic development, and this has led to many uncertainties in the counties where these water bodies are located. Different explanations have been advanced to explain these rising water levels, chief of which is hydro-meteorological variables due to climate change that have led to increased moisture availability as seen in the rainfall data and discharge of the rivers feeding the lakes. There is also increased soil in run off occasioned by land use changes which have increasingly added to the siltation of the lakes as seen in the sediment load in the rivers. All the Rift Valley lakes are situated in faulted terrain in the geologically active Eastern Africa Rift Valley and are therefore mainly controlled by the geological structures. For this reason, the increasing water levels are changing the composition of lake water thus affecting biodiversity. This is manifested in the reduced number of flamingos who feed on algae whose growth has been affected by the change in alkalinity of the lake waters. Biodiversity of the lakes has also been greatly affected by the submergence of the riparian vegetation. Tourism in the areas has drastically reduced owing to the loss in aesthetic value of the lakes and affected incomes. Economy has been further affected by reduced and restricted movement due to Covid-19.

The long periods of the rising water levels in these Lakes have generated a humanitarian crisis. Approximately 75,987 households have been displaced in the thirteen affected counties with a total population of 379,935 requiring urgent humanitarian assistance. The affected communities have endured disruptions to their livelihoods; they have lost assets such as homes, grazing lands and farming fields which have been destroyed and/or marooned by the floods. The rising waters levels have destroyed social amenities like learning institutions (primary and secondary schools), health facilities, markets, fish landing and processing facilities, once-thriving hotels, curio shops, resorts and lodges, electricity lines, water supply and sanitation units (boreholes, shallow wells, sanitation facilities) as well as road networks, forcing many to use boat transport to access services across the flooded areas.

This report intends to highlight the adverse effects of the rising water levels on the affected population and setbacks on the developmental gains. The major effects include loss of lives and livelihoods, injury, outbreak of disease, legal issues, safety and security concerns, and ecological or environmental degradation.

This report is organised into six parts: Introduction, Impact Assessment and Key Findings, Causes of the Rise of Lake Water Levels, Summary of Key Issues, Recommended Interventions, and Conclusions.

The probable cause of the rising water levels

The main reason for the rising water levels is climate change. Evidence for this is provided by the level of rainfall in the catchment areas as documented in the various rainfall gauging stations. There have also been changes in land use practices which have led to increased runoff, in turn causing larger volumes of water to flow directly and rapidly from the land surface into the lakes. The increased inflow of fresh water into some of these lakes has created instability in the already fragile ecology of the lakes, negatively affecting the resilience and distribution of certain water species. In some catchment areas, severe landslides regularly occur. Their cause is largely attributed to anthropogenic threats to the freshwater ecosystems, mainly water quantity effects like deforestation and excessive water abstraction from the lakes, rivers, wetland systems, and groundwater.

Geological controls are also thought to play a role in the current surge of Rift Valley Lakes including Lake Victoria which is controlled by the Nyazian Rift. The entire rift system consists of discrete rift basins which are mechanically linked by zones of rift-oblique faulting. The lakes are a creation of the formation of the Great Eastern Africa Rift Valley in the Pleistocene geological period. At that time, the current lakes covered a much wider area referred to as the Pleistocene lakes. In the historical times and more recently in 1901 and 1963, the lakes showed a significant rise.

The rift escarpments at the edge of the Great Eastern Africa Rift Valley and fault alignments in the rift valley floor are major geomorphic structures controlling the runoff and flows into the rift valley and indeed over the plateaus which continue to shape the present lakes' morphology. They also control and influence rainfall patterns and intensity as the high plateaus play a significant role in the climatic cycles in the area with intensified rainfall occurring there. This has a hydrodynamic influence on the recharge into the lakes.

The key findings presented in this report fall into six categories:

a) Socio-economic Impacts

Lake Victoria, Turkwel Gorge Dam and all the Rift Valley lakes have registered significant biodiversity and socio-economic impacts on the vegetation, wildlife and communities living in these areas. There has been destruction of livelihoods and amenities including basic infrastructure like roads, schools, health centres, hospitality facilities, and fish handling facilities at fish landing sites. The destruction of many hospitality facilities and tourist attraction areas has crippled tourism economy. The rising waters have generally affected an estimated 75,987 households, with a total of 379,935 people at risk. On the positive side, the rising water levels have boosted the fishing industry; there is a projected increase in fisheries potential of the lakes. Recommendations on investments to tap into this resource are given. On the negative side, however, the rising water levels have aided the spread of invasive aquatic weeds like water hyacinth into previously unaffected wetlands.

b) Legal Issues

There are simmering legal challenges due to loss of about 1106 Km^2 (110600 Ha) of land within and adjacent to the lakes. Part of the land that has been submerged has legal title deeds to it, implying that the holders have genuine grievances that will need to be addressed. Some of the owners of lands that have been submerged had however encroached on riparian lands and will need to be moved to safer areas. The government needs to determine the new high-water marks and ensure that new guidelines on the riparian lands are communicated and effectively enforced as impending short rainy seasons may intensify the current problems, creating even more legal challenges.

c) Impacts on Biodiversity

The rich biodiversity areas including wildlife sanctuaries and key Ramsar sites in some of these counties have been greatly impacted. The areas around the lakes which have been associated with such a robust interplay of rich biodiversity of trees, shrubs and important habitat for animal species including numerous species of Kenya's wildlife have all been negatively impacted by the rising waters of the lakes. There is a total annihilation of some of the trees and biodiversity. The worst impacted are the acacia trees, which have dried up and fallen. Increased human-wildlife conflicts have also been witnessed in most of the lakes as animals such as hippopotamus now walk freely within areas that were previously safely occupied by humans.

d) Catchment Hydrology

Unsustainable farming practices and deforestation have significantly degraded the catchments of the lakes. The encroachment on forest land for agriculture and other development purposes has led to stripping off of important forest cover, exposing the land to increased runoffs and hence soil erosion, eventually leading to increased siltation and sedimentation in the lake basins. Unsustainable land use practices within the headwaters and or catchments require focused and in some cases site specific interventions to reduce land degradation. The government should rededicate efforts towards sustainable production practices to stop soil erosion, for instance through planting trees and constructing gabions and trenches to avert continued loss of fertile soil and increasing sedimentation in the lakes. Although silt removal is quite expensive, this should be considered because most of these lake ecosystems are choking with silt and soil sediments.

e) Geological controls

A number of geological controls are linked to current surge of lake water levels. First, the East African Rift Valleys (EARs), being an active tectonic belt, is characterized by extensional stress-regime where myriad of tectonic forces continues to shape the present rift geometry including the segmentation of the rift lake basins. Such forces include magmatic stresses that have led to formation of major volcanic edifices and increased seismic activity.

Second, groundwater saturation within the rift valley lake basins poses eminent threats to the discharge of lake water. There is likelihood of potential subsurface groundwater exchange due to saturation resulting in an unbalanced negative moisture budget. The impacts of groundwater saturation within the fault-pathway networks are thought to limit underground out-flow from the water bodies. The varied hydrodynamics within the rift lake basins due to increased precipitation are thought to be responsible for the current phenomenon. As such, the increased lake water levels within EARs suggests that the lake basins could be experiencing periodic isostatic adjustments compounded with neotectonics deformation. This has the potential of creating asymmetry of water bodies within the rift systems creating escape routes for the waters and subsequent reduction of lake water levels.

Lastly, the location of these lakes within an active tectonic belt, where open faults and fractures continue to dissipate a significant number of magmatic gases like Carbon Dioxide (CO_2), increases the likelihood of high CO_2 concentration within these water bodies, raising major concerns on safety implications. This is likely possible considering that some of the submerged famous geysers and hot springs at Lake Bogoria could potentially lead to gas saturation. Such phenomenon is also likely to be replicated across all the other lakes due to the faulting nature of the basins.

f) Security Issues

There have been increased cases of human-wildlife and inter-community conflicts in the areas in question. For instance, in Lake Baringo/Bogoria, Rukos Island wildlife sanctuary was submerged, forcing wildlife to relocate. Also submerged in the area were a GSU-RDU camp, KEMFRI labs, the Fisheries department, and other government and private facilities including hotels. The residents of Partalo, Ilgurme and Nosidan villages increasingly feel insecure after the rising water levels pushed them out of their ancestral land onto other people's territories where they are now competing for pasture. As for human-wildlife conflict, most lake basins reported increased incidences of human-wildlife conflicts, particularly those involving animals like buffalo, *Hippopotamus amphibious,* crocodiles and snakes which moved closer to the villages hence posing a threat to the community and their livestock.

In Lake Magadi basin, security issues revolve around of loss of lives and livestock due to flash floods, exposed fault lines and sinkholes in Nairage Enkare; unease within the Purko pastoral community at the construction of the silt diversion dykes; and vandalism of galvanized steel wires that support the gabions at the diversion point for own use. In the Turkwel Dam area, there has been increased tension between Pokot and Turkana communities due to loss of grazing lands and lack of awareness of the dam operation mechanisms, especially the concern over the potential of dam spillage downstream.

The summary of the extent of flooding and the changes in the surface area of these lakes from their normal size to the onset of the level rise in 2020 is shown in Table 1. Landsat imagery was used to digitize and compute the changes in surface area in 2010, 2014 and 2020 shown in table 1.

Table 1: Extent of the Rift valley lakes as mapped from the Kenya Topographic sheets and Landsat Images of 2010, 2014 and 2020.

S/N	Lake/Dam	Toposheet (km^2)	2010 Extent (km^2)	2014 Extent (km^2)	2020 Extent (km^2)	Change (2020–2010)	% Change	Change (2020–Normal)	% Change from Normal
1	Turkana	7,485.48	7,947.85	8,064.09	8,265.07	317.22	3.99	779.59	10.41
2	Logipi	129.88	183.46	178.43	190.93	7.47	4.07	61.05	47.00
3	Baringo	128.08	159.49	221.77	268.06	108.57	68.07	139.98	109.29
4	Bogoria	34.35	34.79	40.5	43.25	8.46	24.32	8.9	25.91
5	Solai	5.74	9.54	13	13.61	4.07	42.66	7.87	137.11
6	Nakuru	40.04	45.01	56.82	68.18	23.17	51.48	28.14	70.28
7	Ol'Bolossat	18.2	39.81	50.39	52.16	12.35	31.02	33.96	186.59
8	Elmenteita	21.24	21.54	22.78	22.97	1.43	6.64	1.73	8.15
9	Naivasha	135.32	154.16	164.86	193.48	39.32	25.51	58.16	42.98
10	Magadi	141.09	148.09	150.9	153.3	5.21	3.52	12.21	8.65
11	Victoria	3,971.37	4,030.22	4,421.32	4,572.7	542.48	13.46	601.33	15.14
12	Turkwel Dam	18.97	22.97	31.68	59.27	36.3	158.03	40.3	212.44
	Total	**12,129.76**	**12,796.93**	**13,416.54**	**13,902.98**	**1,106.05**	**8.64**	**1,773.22**	**14.62**

2010, 2014 and 2020 data are based on GIS Landsat8 Satellite imagery of 28m spatial resolution

Recommendations

The Government undertakes to follow up with the recommendations in this report. These are categorized as short-, medium- and long-term actions. The interests of the local communities and the biodiversity within these areas is quite prominent and should drive any further interventions and plans by the government, both at the County and National level, to avert the continued rise and the resultant negative impacts on people and biodiversity. Based on the scoping mission report, the following recommendations are made:

i) Immediate intervention Measures

a) Immediate humanitarian assistance should be provided to the affected communities in form of food and non-food items as well as incentives, subsidies, and cash transfers to enable them cope with the crisis. Non-food items and services include shelter and shelter kits, emergency health services, health and nutrition, portable water, hygiene and sanitation facilities, and psycho-social support which is urgently required in the immediate phase.

b) Public engagements should be initiated between the government and affected persons to assure the people of the government's commitment to supporting them. This is a crucial a first step towards getting the affected persons back on their feet.

c) Awareness on climate change should be created using simple illustrations that would lead to co-creation of solutions. This should include addressing the issue of increasing human-wildlife conflicts.

d) Lake levels should be closely monitored. This is necessary as it helps avert hazards in the future.

e) Meteorological patterns should be closely monitored, and simulation of future scenarios should be advanced as part of immediate intervention approaches.

f) Rapid assessment of the impacts of rising lake levels on biodiversity and food security needs to be conducted in the affected areas.

The short-term interventions (0–3 months) are estimated to cost KSh: 2,924,843,176

ii) Short-term Intervention Measures

a) Rehabilitate, relocate, and restore damaged infrastructure such as water supplies, sewerage plants, fish handling facilities, health centres, electricity supplies, roads, schools, police stations and police posts as per the specified requirements.

b) Carry out flood control and conservation practices in catchment areas to reduce the impact of flood water on livelihoods and properties in general. Green Recovery approaches such as enhancing green infrastructure should be adopted. This will help enhance the percolation of rainwater and improve recharge of shallow unconfined underground aquifers which are integral to minimizing risks and impacts of rising water levels.

iii) Carry out a focused study on the hydrochemistry of the lakes, particularly on isotope studies and on monitoring the saturation of carbon dioxide to understand the dynamics of each lake and the associated hazards due to swelling. This can be expanded through engaging WRA sub-regional offices and County Governments for speedy execution. Medium-term Intervention Measures

a) Studies should be conducted on land use, land cover, and water balance on all the lakes and their respective basins to inform establishment of the highest water mark under the worst-case scenarios in the history of the lakes to help in clearly defining and demarcating boundaries around the lakes.

b) The government should consider buying off the affected areas to create a buffer zone.

c) Groundwater monitoring boreholes should be drilled to determine the likelihood of episodic recharge within the aquifers during heavy rains against the saturation potential of groundwater. This is geared towards monitoring potential isotactic adjustments that may be catastrophic. There is also a need to carry out research on tectonic movements and magmatic stresses including seismic monitoring to detect active zones potentially in distress due to swelling lakes. This should be conducted together with bathymetric studies to determine the depth of lakes and sedimentation.

iv) Long-term Intervention Measures

a) Finalize and implement the National Lake Basin Management Strategy which is at the Ministry of Water and Irrigation. The purpose of the strategy is to provide an integrated framework for the sustainable management and use of Lake Basin resources through informing policies, strategies, plans, projects and programmes, as well as to guide coordinated actions. It embraces all institutions mandated to manage and conserve land, water and other resources within each lake basin; recognizes the role of the public and other stakeholders in the conservation and governance of lake basins; embraces appropriate and practical state-of-the-art technologies and innovations which advance conservation and sustainability of water resources; advocates for a strong data, knowledge and information system for evidence-based decision making at all levels; and explores opportunities for broad-based financial mobilization.

b) In addition, the Government should re-dedicate efforts to support all the 47 Counties to prepare Climate Resilient County Spatial Plans (CRSPs) that will anticipate such challenges in a more predictive manner. The CRSPs should clearly delineate the new proposed high-water marks and provide clear land use and physical planning guidelines that will avert the continued developments in areas considered as riparian areas, under the relevant laws.

Financing

The Government should set aside a budget for resolving some of the challenges identified in this report. Other partners should also be mobilized to contribute towards sustainably managing this challenge. Partners like United Nations Development Programme (UNDP) and United States Agency for International Development (USAID) among others should support the efforts to coordinate measures respond to this issue adequately and sustainably.

Conclusion and Way Forward

Given the magnitude of this challenge, the Government will partner with UNDP and other multilateral and bilateral partners to mobilize the much-needed resources through a multi-donor programme that will seek to resolve the short-, medium- and long-term issues identified in this report. The Government and UNDP together with other partners will move to secure broad-based ownership and support of a comprehensive programme that will seek to sustainably manage any future occurrences.

1 Introduction

1.1 Background

Kenya is divided into six major water catchments areas namely: Athi River Basin Area, Tana River Basin Area, Ewaso Ngiro North Basin Area, Rift Valley Basin Area, Lake Victoria South Basin Area, and Lake Victoria North Basin Area (see Figure 1 that is based on Water Resources Authority's 6 river basins) and can be grouped into the following topographic domains and drainage controls:

(i) The basins that drain off the Eastern Escarpment of the Rift Valley source their waters from the high mountain areas of Mt. Kenya, Aberdare, Nyambene Hills, Ngong Hills, and Laikipia Plateau and drain into the Indian Ocean;

(ii) The basins that drain off the Western Escarpment of the Rift Valley source their waters from Mau Complex, Uasin Gishu Plateau, Cherangany Hills, Loita Hills, and Mt. Elgon and drain into Lake Victoria. Significant volcano-tectonic features in the area are Nandi Escarpment, Soita Ololol Escarpment, Tinderet Volcanic dome, Winam Gulf, Kavirondo Valley and Homa, Ruri, Gemba, Rangwe and Gwasi Hills; and,

(iii) The other major drainage is internal into the Rift Valley lake basins of Magadi, Naivasha, Elmenteita, Nakuru, Bogoria, Baringo, Logipi, and Turkana, which source their waters from the Eastern and Western Rift Valley Escarpments, Cherangany Hills, Tugen Hills, Mt. Elgon, and higher volcanic hills within the rift floor (Shompole, Ilkeek Loolkokoyo, Suswa, Longonot, Olkaria, Eburru, Menengai, and Kipipiri). In most parts, the drainage flows down the face of the escarpments into the lakes and are controlled by the fault dominated volcano-tectonics of the Rift Valley area.

Recent concerns on the rising lake water levels led to the scoping mission that targeted lakes in the Rift Valley and Lake Victoria. From observations and topographic analyses made, there is influence on the flow from the Central Rift Valley floor around what is geologically referred to as the Kenya Dome at Eburru-Olkaria-Longonot volcanic complex, Bahati Hills fracture zone and Menengai Caldera that mark a drainage divide between the runoff to the northern depression (with a low at Lake Turkana – 361m asl) and to the southern depression (with a low at Lake Magadi (603m asl at the lowest). Lakes Naivasha (1883m asl), Elmenteita (1776m asl), Nakuru (1757m asl), Bogoria (991m asl) and Baringo (968m asl) are located on the Kenya Dome. Lakes Naivasha and Baringo are freshwater lakes and maintain a freshwater fishery.

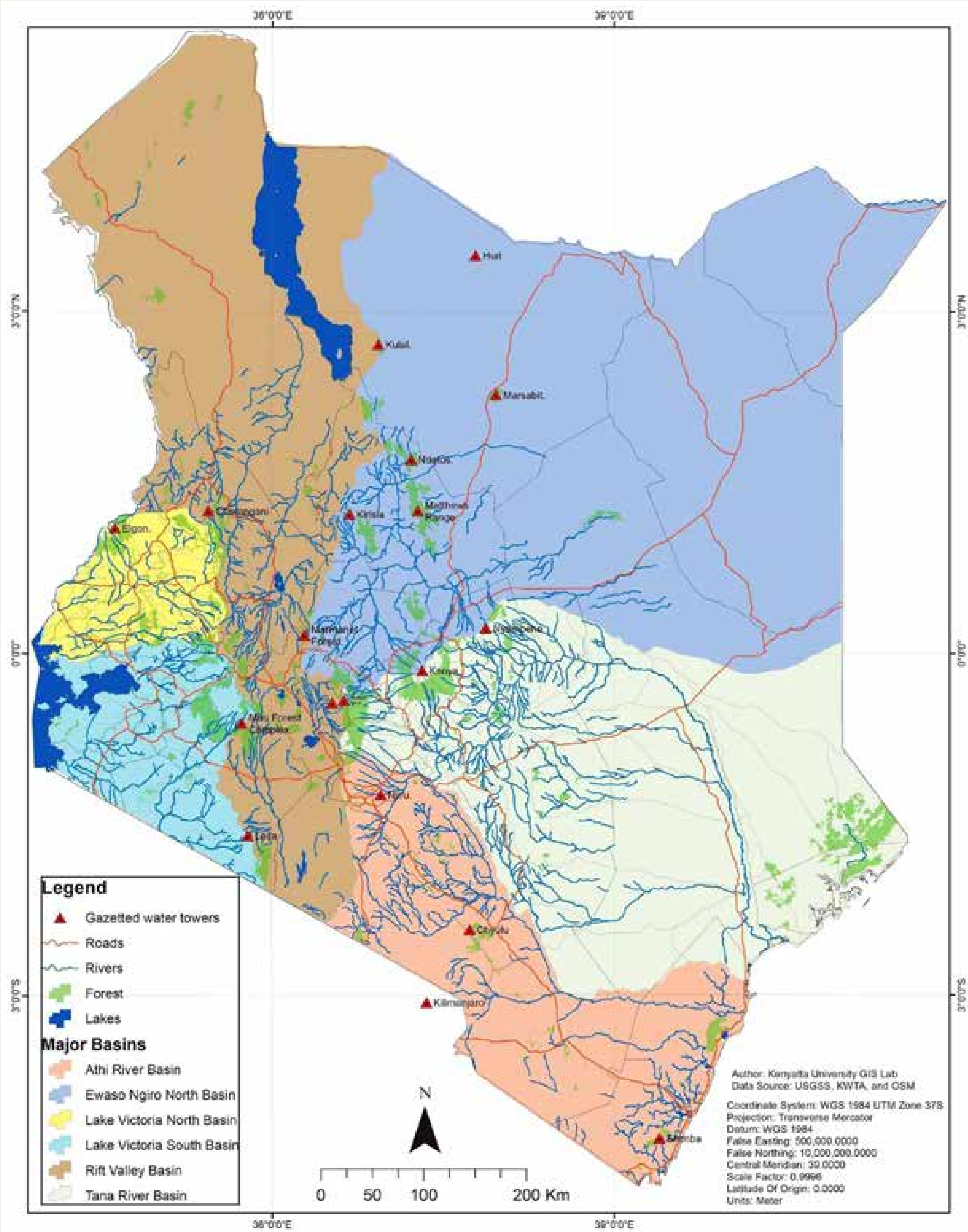


Figure 1: Kenya's Six Major River Basin Areas

The volcano-tectonic regimes that created the Eastern Africa Rift Valley led to development of topographic escarpments that now control the rainfall and drainage flow patterns and intensity as follows:

(I) Mount Kenya, Aberdare and Nyambene Hills Watershed Zone that serves Athi River, Tana, Ewaso Ngiro North, and the part of the Eastern Escarpment areas draining into the Rift Valley basins (Lake Ol' Bolossat and Lake Naivasha);

(ii) Mau Complex Watershed zone that serves Mara River, Ewaso Ngiro South, Migori, Sondu/Miriu, Nyando, and Kuja River (draining off Kisii Highlands) and part of the Western Escarpment areas draining into the Rift Valley basins (Lake Magadi, Lake Nakuru, Lake Elmenteita, and Lake Solai);

(iii) Mt. Elgon, Cherangany Hills, Uasin Gishu Plateau, Elgeyo Escarpment serving Nzoia River and Yala River that drain into Lake Victoria; and Tugen Hills covering the part of the Escarpment draining into Lake Bogoria, Lake Baringo, and Kerio and Suguta Rivers;

(iv) Turkwel River Basin area draining off Mt. Elgon, Cherangany Hills, Kapcholio, Kachagalau, Moroto and Kadam Mountains in Uganda; and Karasuk, Murhaikit, Ngapoi Hills that drain into Lake Turkana and the part of Kerio River and Suguta River also draining into Lake Turkana; and,

V The drainage area north of Ewaso Ngiro North consisting of River Danoro, Daua, Laga Bor, Afgudud, Kutulo, and Bogal, draining off Marsabit Hills and Losiolo Escarpment area.

1.2 The Scoping Mission on the Lakes and Dams

1.2.1 Methodology

The Multi Agency Team used two approaches to collect information on the causes and socio-economic impacts of rising water levels on the Great Rift Valley lakes, Turkwel Gorge Dam and the Lake Victoria, namely, satellite image processing and GIS overlay, and field scoping by teams.

1.2.1.1 Satellite Image Processing and GIS Overlay

1 Arc-second Digital Elevation data was downloaded from the United States Geological Survey (USGS) data repository available at https://earthexplorer.usgs.gov/ and used to develop Digital Elevation Models (DEM) from NASA's Shuttle Radar Topography Mission (SRTM) 30m resolution elevation global raster Grids using ArcGIS model builder. The 3-dimensional visualization technique supported the development of a shaded relief model that was used to determine the slope angle and attitude for measurement and analysis of runoff flow direction and therefore delineation of the watersheds and the drainage areas.

For the classification of land cover, mosaiced Landsat satellite image bands of various years (2000, 2010, 2014 and 2018) were composited to false colour images by combining three image bands namely the infrared, red and green. These have been used by the Directorate of Resources Surveys and Remote Sensing (DRSRS) for identification of different types of land cover. The composited images were classified using Random Forests (RF), which uses supervised classification algorithms. RF procedure begins by the operator selecting training samples from the composite imagery, which are then used by a program script in a statistical language 'R'. The RF procedure fits many separate trees, each to a randomly selected subset of the training data. Each pixel is given a class label from each tree, and the relative frequencies of a pixel's class allocations from the multiple trees are used as measures of classification confidence. Additionally, the RF procedure produces summaries as indicators of the accuracy of classification derived from the training data. Seven classes of land cover were considered for this case: Forestland, Wooded Grassland, Open Grassland, Cropland, Vegetated Wetland, Open Water and Other Land.

Pixel based Iso Cluster Unsupervised Classification algorithm in GIS software was applied, which grouped pixels of image with the same digital values of image reflectance to the same categories of land cover. The software was instructed to classify the images into 100 different categories for high precision and accuracy during classification, with the categories being identified by numeric values of 1 to 100. The classified images were reclassified to change the numeric classes to the corresponding types of land cover. Reclassification was based on the work done by the image analyst and ground information knowledge, resulting in the identification of ten types of land cover: forest land, shrubland, grassland, wetlands, settlements, cropland, cropland/grass, cropland/shrubs, cropland/other land and other lands.

The delineated watersheds were superimposed on the images to help determine the characteristics of the areas from which the rivers are sourced. An overlay of the watershed area also supported characterization of the catchment area and therefore the drainage basin.

1.2.1.2 **Field Scoping by teams**

The scoping missions involved seven to ten days of simultaneous fieldwork activities on and around each of the ten lakes. The Turkana team used an additional 7 days to scope the eastern sides of lake Turkana in Marsabit County. The field trips followed consultation among the teams during a retreat in Naivasha and further engagements for groundwork activities with the County Commissioners and the County Governments of the affected counties. Travel and logistics were supported by UNDP through the Ministry of Environment and Forestry.

The visits to the lakes allowed the scoping teams to:

(i) Make observations and gather data on the impacts and the actual extent of the flooding by measuring the location of the water on the ground using Geographic Positioning Systems (GPS) for geolocation;

Engage in a participatory assessment of the expanse of the lakes through consultations and interviews with the affected communities;

(ii) Hold consultative meetings with the County Commissioners and the respective Heads of Government Departments in the counties;

(iii) Hold consultative meetings with the departments responsible for Public Service, Environment, Water and Disaster Risk Management in the County Governments in question;

(iv) Establish the possible causes of the rise of lake water levels and to find out from the community elders and the local administration whether this phenomenon had been experienced in the past. In some cases, focused group discussions were used to achieve this; and,

(v) Visit various affected development infrastructure, make observations, and document the extent of the impacts using photographs.

The morphology, resources and conditions of land use were recorded and related to locations on the ground so that notes and photographs could be studied in relation to the physical impacts on the lakes.

1.2.2 Data Collection Tools

The teams employed both qualitative and quantitative research methods during the scoping mission that was carried out between 21 October and 1 November 2020. The main goal of the scoping mission was to investigate probable causes of rising water levels in various lakes and dams, and to highlight the resulting social, economic, legal and security implications on the neighbouring communities and the effects this phenomenon has had on biodiversity in these regions. The teams selected specific affected areas in which they collected data. The tools employed for data collection included: Focus Group Discussions (FGDs), Key Informant Interviews (KII), Direct Observations (DO) and Geographical Information System (GIS). The questionnaire used during data collection is provided in Appendix 3.

The following methods were used in collecting the data:

(i) Extensive tour of selected sites around the ten lakes and one dam;

(ii) Interviews with the leadership of affected areas, mainly National Government and County Government officials;

(iii) Literature review particularly of recent reports and data from key government institutions and other stakeholders;

(iv) Extensive interactive discussions with heads of government departments and institutions in the affected Counties. These departments included those of Environment, Water, Agriculture, Livestock and Fisheries, Education, Wildlife, and Social Services;

(v) Administration of questionnaires to key respondents;

(vi) Interaction and discussions with local leaders such as Chiefs and selected members of the Beach Management Units within the Counties;

(vii) Assessment of major rivers and National Irrigation Schemes including rapid tours of some sections of the wetlands such as Yala and Kanyaboli;

(viii) Taking GPS positions and photographic evidence at all the sites;

(ix) Using 30m Landsat satellite imageries of 2000, 2010, 2014 and 2018 to analyse patterns of land use and land cover and to conduct an analysis of time series area coverage;

(x) Receiving petitions from the affected groups around the ten lake ecosystems;

(xi Observation of the hotspots impacted by the flood waters; and,

(xii) Statistical analysis of data on hydrometeorology and water quality.

1.3 Situating the Lakes: The structure of the Rift Valley and its role in the rising lake water levels

1.3.1 Geological controls on the dynamics of rising lake water levels in Rift Valley

The lakes are a result of the formation of the Great Eastern Africa Rift Valley that started around the onset of the Miocene, 22–25 million years ago. The Miocene basalts are mainly located north of the Laikipia Escarpment in Marsabit and appear to have been emplaced through lines of weaknesses in ancient Precambrian metamorphic rocks (Smith and Mosley, 1993) when the initial rifting took place. The Eastern Branch of the Eastern Africa Rift systems is known as the Gregory Rift (Bosworth et al, 1986), or the Kenya Rift, and contains the East African Great Lakes. The Kenya Rift together with the Western branch of the Rift valley along with the Ethiopian Rift is what creates the East Africa Rift System forming a sequence of related rift basins that create the distinctive topography and geology of Eastern Africa that includes the Lake Victoria basin.

The continental rifting that led to the formation of the rift valley started in the Red Sea where, at the Afar Depression, the rift floor is below sea level. The rifting cut through Djibouti, Ethiopia, Kenya, Tanzania and into Malawi and Mozambique. The rifting is a divergent zone separating the Nubian and Somalian tectonic plates and is therefore a zone of runoff and flow accumulation. In Kenya, the Rift Valley is above the sea level and is occupied by lakes at various locations and elevations. Three distinct basin areas are identified as follows:

a) The Turkana Basin containing Lake Turkana (361m asl) and Lake Logipi (273m asl) that is bordered by Elgeyo-Nakeretin-Marua-Erith, Lapurr and Losiolo Escarpments;

b) The Kenya Dome basins containing Lakes Naivasha (1883m asl), lake Oloidien (the Small Lake, 1885m asl), Elmenteita (1776m asl), Nakuru (1757m asl), Bogoria (991m asl), Baringo (969 m asl), Solai (1512m asl) and Ol' Bolossat (2328 m asl) bound by Sattima–Marmanet-Laikipia Escarpment on the east and Mau Escarpment on the west; and

c) The Lake Magadi basin containing Lake Magadi (603m asl) and Ewaso Narok South Wetland swamp (609m asl) at the foot of Shompole Volcano and is bordered by Nguruman Escarpment to the west and the Kikuyu-Ngong Escarpment to the east.

The initial rifting occurred in the Miocene through Tertiary period and led to significant extrusion of basaltic lava flows that mark the eastern area of the Lake Turkana landscape in Marsabit and the Laikipia plateau. In the Pleistocene there was another intensified period of tectonic and volcanic activity marked by phonolite lava flows and pyroclastic ash eruptions that mark the terrain of Uasin Gishu Plateau, Kinangop Plateau, and Kaputei-Nairobi plateau. Most geological prepositions indicate a magma intrusion and a flow of heat from under the mantle that is causing thermal swells in Ethiopia's Afar region and the Central Kenyan part of the Rift Valley commonly referred to as the Kenya Dome.

The rift escarpments at the edge of the Great Eastern Africa rift valley and fault alignments on the floor of the rift valley are major geomorphic structures that control the runoff and flows into the rift valley and indeed over the adjoining plateaus (Onywere, 1997). The escarpments and the faults control and influence rainfall pattern and intensity as the high plateaus play a significant role in the climatic cycles in the area, with intensified rainfall occurring at the major escarpments. This has a hydrological and hydrodynamic influence on the infiltration, run-off and recharge into the lakes.

1.3.1.1 **Tectonic Framework of the Rift Valley**

The East African Rift System in Kenya consists of the splay-faulted northern depression of Bogoria-Baringo-Turkana basin, which is one of the three tectonic terrains (blocks). The other two blocks are the southern depression of Magadi-Natron basin and the step faulted central block of Nakuru-Elmenteita-Naivasha basin. The three blocks are separated by zones of cross-structures, multi-fractures and displacements, representing accommodation zones of complex wrench and oblique slip faults (Morley et al 1990 and Bosworth et al 1986). The near N-S elongated block structures are detached on one side from the main bounding faults. On the other side they are marked by a fault flexure. The Bogoria-Baringo-Turkana basin occupies the Elgeyo detachment and derives its name from Elgeyo Escarpment from which it is detached. It is bordered to the east by the Laikipia Escarpment and separated from Kerio Valley by a host block formed by the Tugen Hills. The Magadi-Natron basin occupy the Nguruman Escarpment which is bordered to the east by the Kikuyu escarpment, while the Nakuru-Elmenteita-Naivasha basin occupy the Sattima-Aberdare Escarpment which is bordered to the west by the Mau Escarpment on which sits the Mau Hills complex.

Normal faulting is the predominant mechanism of deformation within the Rift Valley floor. The variation in orientation of fault systems is attributed to paleo-stress permutations which control different partitioning episodes between faulting and magmatism (Chorowicz, 1992; Chorowicz, 1990). The central rift sector manifests shear-strain partitioning zone where the westerly trending Nyanzian rift and north westerly trending Anza lineament emerge (Figure 2).

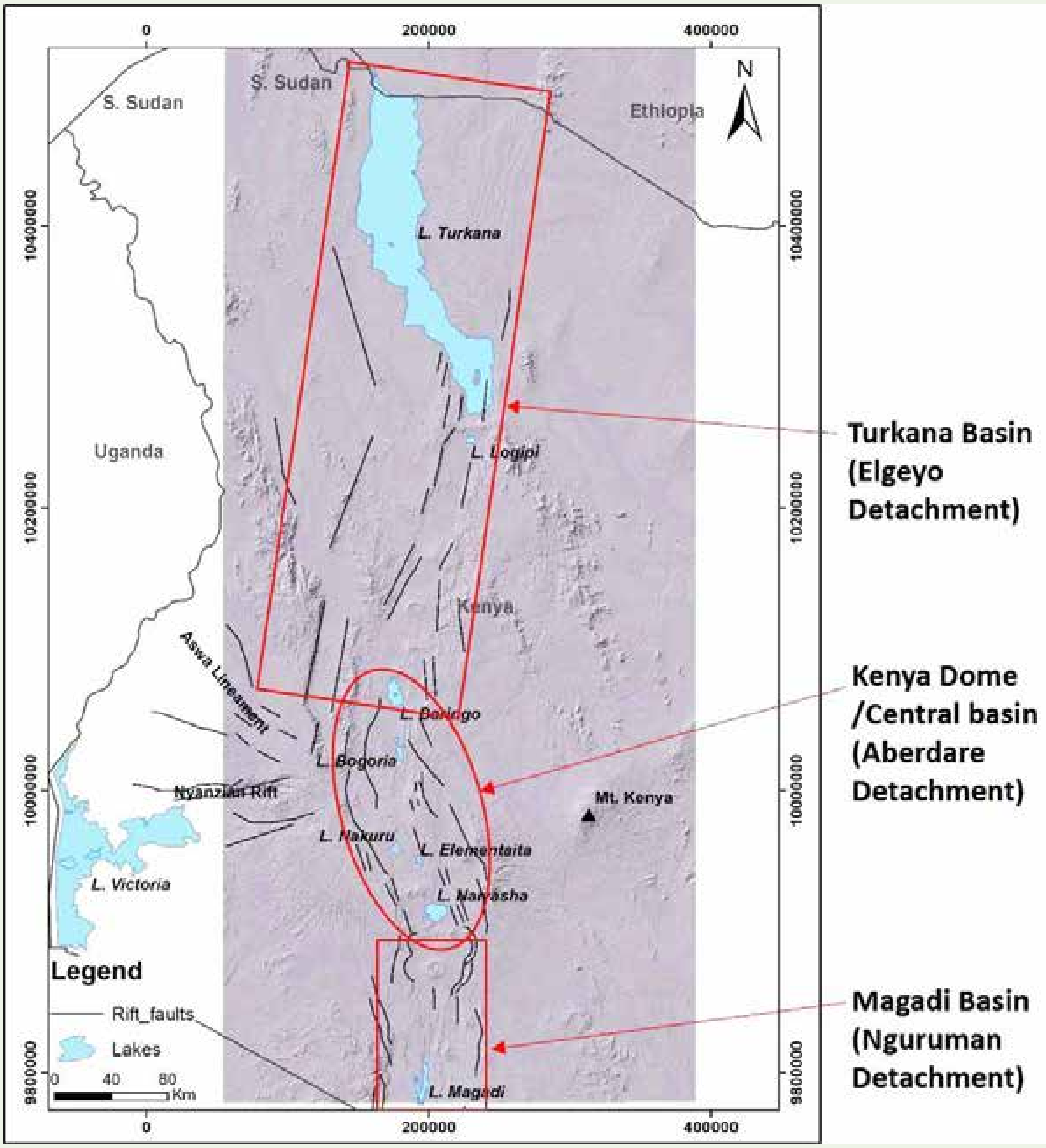


Figure 2: Tectonic framework of the Kenya Rift Valley System and associated rift valley lakes

1.3.1.2 The Turkana Basin area

The topography is striking, a product of the East African Rift Valley tectonism and volcanism. The Elgeyo escarpment runs N-S for 140 km in its section between Biretwo and Marich Pass. At its southern end the escarpment trends NNE-SSW for at least 30 km ending at the Metkei Highlands.

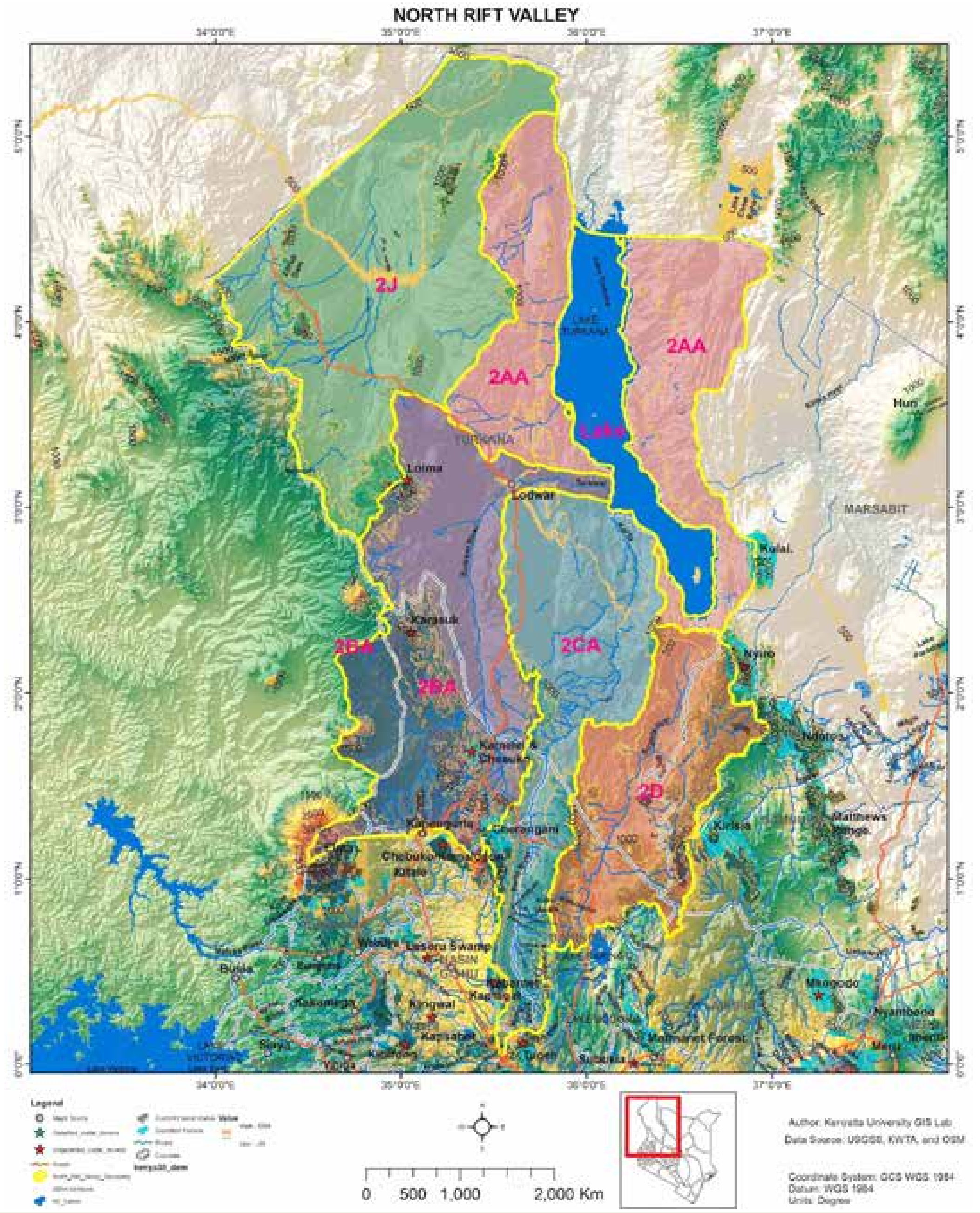


Figure 3: The DEM of Lake Turkana Basin showing the control on the drainage by Elgeyo, Merich and Laikipia Escarpments

The top of the escarpment is a clear line of 200–300 m thick phonolite cliffs. A 250–300 m thick bench or step of basalt cliffs underlies the phonolites. At the base of the basalt cliffs is another bench, marking Kimwarer sediments (part of Turkana grits) of Tertiary age that give way to the Precambrian metamorphic rocks on the floor of the rift (Aljabri, 1990). The Kerio Valley itself is a 10–15 km wide trough, widening to 25 km to the north and lies between 1000m to 1300 m asl. The drainage is controlled by the major escarpments and fault systems as seen in the DEM (Figure 3). The basin area of 109,985 Km^2 is served by only 1.3% of forest cover (see forest areas in Table 2).

Table 2: **The watershed (drainage basin) areas and the gazetted and current (digitized from Google Earth Images) forest areas**

NORTH RIFT						
Basin Code	**Name**	**Watershed (km^2)**	**Gazetted Forest (km^2)**	**Forest % in watershed**	**Current Forest (km^2)**	**Forest % in watershed**
2J	Lorus	27,813	168	0.60%	329	1.18%
2AA	Lakeshore	7,314	1	0.01%	40	0.55%
2D	Suguta	21,496	210	0.98%	431	2.01%
2BA	Turkwel	13,016	1,219	9.37%	310	2.38%
2CA	Kerio	22,953	1,124	4.90%	320	1.39%
Lake	L Turkana	130,860	0	0.00%	0	0.00%
Total	**North Rift**	**223,452**	**2,722**	**2.47%**	**1430**	**1.30%**
CENTRAL RIFT						
Basin Code	**Name**	**Watershed (km^2)**	**Gazetted Forest (km^2)**	**Forest % in watershed**	**Current Forest (km^2)**	**Forest % in watershed**
2GA	Ol' Bolossat	571	67	11.73%	0	0.00%
2FB	Nakuru	1,707	512	29.99%	239	14.00%
2GB	Naivasha	3,362	547	16.27%	313	9.31%
2FA	Elmenteita	567	0	0.00%	74	13.05%
2EB	Bogoria-Solai	1,172	37	3.16%	24	2.05%
2EJ	Baringo	6,666	590	8.85%	480	7.20%
Total	**Central Rift**	**14,045**	**1,753**	**12.48%**	**1,130**	**8.05%**
SOUTH RIFT						
Basin Code	**Name**	**Watershed (km^2)**	**Gazetted Forest (km^2)**	**Forest % in watershed**	**Current Forest (km^2)**	**Forest % in watershed**
2KA	Ewaso Narok South	8,723	1,477	16.93%	909	10.42%
2H	Magadi	8,299	153	1.84%	160	1.93%
Total	**South Rift**	**17,022**	**1,630**	**9.58%**	**1,069**	**6.28%**

LAKE VICTORIA						
Basin Code	Name	Watershed (km^2)	Gazetted Forest (km^2)	Forest % in watershed	Current Forest (km^2)	Forest % in watershed
Lake	L. Victoria	3,752	0	0.00%	0	0.00%
1HA	Siaya ()	2,242	32	1.43%	12	0.54%
1HAA	Homabay ()	2,843	0	0.00%	78	2.74%
1LA1	Mara	8,975	1,271	14.16%	608	6.77%
1KC	Gicha-Migori	6,892	0	0.00%	111	1.61%
1JA	Sondu-Miriu	3,504	752	21.46%	630	17.98%
1GA	Nyando	3,627	576	15.88%	506	13.95%
1FA	Yala	3,297	315	9.55%	389	11.80%
1BA	Nzoia	12,717	1,730	13.60%	1,330	10.46%
1AA	Sio	2,317	210	9.06%	146	6.30%
Total	**Victoria**	**50,166**	**4,886**	**9.74%**	**3,810**	**7.59%**

The Tugen Hills are parallel to the two walls of the Rift Valley and form a 110 km long, steep ridge (1000–1500m) between the Kerio and Bogoria-Baringo troughs. The central crest of the ridge is narrow, less than 10 km in some places. The eastwards-facing escarpment of the Tugen Hills in many ways resembles the lithologic characteristics of the Elgeyo Escarpment between latitudes 0º 30´ N and 0º 50´ N. The Bogoria-Baringo trough and the Suguta valley floors are covered by Tertiary and Pleistocene volcanic provinces.

On the eastern parts of Lake Turkana are a series of fault blocks and graben with intervening grabens flooding only during rains that are rare in this part of the country. The Chalbi Desert is a significant plain that occasionally fills up with run-off water draining the surrounding basaltic lavas that are caping the plains to its north and east.

The main geological formations observed in this area can be summarized as follows:

(i) The Precambrian basement system;

(ii) Lower Miocene sediments;

(iii) Upper Miocene volcanic rocks;

(iv) Plio-Pleistocene;

(v) Pleistocene; and,

(vi) Quaternary and Recent deposits.

Lake Turkana is a large, closed-basin lake which in the geological past overflowed first to the Indian Ocean and then, after about 1.3 million years ago, into the Nile drainage basin. The lake's catchment basin covers an area of approximately 130,860 km^2. With a surface area of about 7,560 km^2, the lake is 260 km long with an average width of 30 km, a mean depth of 31 m, and a maximum depth of 114 m. It is fed by three major rivers: the Omo, Turkwel, and Kerio. Numerous small seasonal streams also discharge into the lake. The Omo River, which flows continuously and is fed by precipitation from the Ethiopian Highlands, accounts for more than 90% of the lake's freshwater influx and acts as the lake's "umbilical cord". Turkwel and Kerio rivers, on the other hand, have their sources in the Cherangany Hills forest reserves.

The lake lies in a broad, arid depression surrounded by late Cenozoic fluvial, lacustrine, and volcanic sequences. The climate of the Turkana basin is hot and arid, with extended periods of unusually intense diurnal winds. Seasonal variability in air temperature and rainfall is much subdued compared to the other great lakes of East Africa. The temperatures of the lake range between 24.5ºC and 30º C, its salinity is about 2,500 mg/l, and the entire water column is oxygenated by strong wind currents and waves throughout the year.

Despite its large size, Lake Turkana is a highly pulsed, variable system, a result of its closed-basin nature, arid surroundings, and its strong dependence on the Omo River for its inflow. As a result, the lake is sometimes called an "amplifier lake", that is, it "amplifies" changes in climate. The water budget of the lake is balanced between river inflows, groundwater exchanges, and evaporation losses. The hydrological budget of the lake is dominated by input from the Omo River loss by evaporation. Primary production in the lake is about 700–800 gC/m2y and is typically limited to the upper 6 m of the turbid water column. This lake has experienced fluctuations of more than 100 m in response to climate change. Analyses of sediment cores from within the modern lake and of lake deposits exposed onshore indicate that Lake Turkana overflowed into the Nile in the early Holocene (11.5–7.8 and 7.4–4.3 kyr), at 102 kyr, and at 195 kyr, with possible links at 123 kyr and 172 kyr as well. Geochemical composition of much older (2.8–0.7 Ma) lacustrine sediments exposed to the east of the lake also suggest periodic overflow to the Nile, but the exact timing of these events is yet to be worked out. It is also likely that the water levels in Lake Turkana were much lower during the last ice age and at in other times of weakened African monsoon. It may even have completely dried up once.

1.3.1.3 **The Central Rift Valley (Kenya Dome)**

The Aberdare Detachment System area is covered by bedrock of spatially extensive and voluminous volcanic material mainly consisting of faulted tuffs and lavas of varying composition that range from under saturated tephrites to highly acidic rocks such as rhyolites and silicic rhyolites exposed in Olkaria area. These rocks have been widely studied mainly because of their accessibility. As noted by Baker and Mitchell (1976) and Hackman (1988), only young volcanic rocks are exposed on the well-preserved escarpments within the Aberdare Detachment. Baker and Wohlenberg (1971) indicate that the volcanic rocks on the floor of the rift appeared after extrusion of flows of lava and pyroclastic which filled a previously much deeper graben and concealed the structures of the fault. The thicknesses of the young volcanic rocks are thus much greater than the present topographic relief of 2000 m above the rift floor. Deep wells at Olkaria area (over 2000 m asl) reveal volcanic material in a 2484.6 m deep well (well OW-18), one of the deepest wells for geothermal exploration in Olkaria area (source: Kenya Power Company Limited, Olkaria Power Station, 1992). This thickness of volcanic matter, together with the heights of the adjoining escarpments, suggest throws of well over 4000 m along the major escarpments. Baker (1986) proposed throws of up to 10000 m (10 km).

The sub-basin overlying the Aberdare Detachment is located at the crest of the Kenya Dome and displays fault-controlled topography, with local step-fault platforms on either side of the main graben. The major faults are arranged in *en échelon* patterns (Chorowiz, 1987), with the blocks between overlapping faults broken up and stepped down in numerous smaller faults, instead of forming simple strike ramps. Complex minor fault systems are also seen in synthetic transfer zones within the floor of the rift. In the Solai-Subukia, Bahati and Gilgil areas, they form polygonal fault-bound structures (box faults) and rhombus-shaped structures. The DEM of the area (Figure 4) Illustrate these topographic regimes. In a total basin area of 14045 km^2 the forest cover occupies only about 1130 (8.05%) currently, which is a significant reduction from the gazetted forest area of 1753, 12.48% (Table 2).

Except for local rainfall variations at the major volcanic centres in the Kenya Dome, there is a general decrease of rainfall from the rift shoulder escarpments into the rift floor and from the highest part of the floor of the rift at Menengai, towards the south and north. A large part of the study area receives rainfall less than 700 mm annually, with Elmenteita "Badlands", Gilgil and Marigat areas receiving the least (< 500 mm). Rainfall reliability is also very low in Solai and Lake Bogoria areas as well as in the plains around Lake Naivasha and Longonot volcano.

The wide variations in climate, geology and topography in the Aberdare Detachment is reflected in soils, which vary from slightly altered volcanic ashes and pyroclastics in Longonot-Nakuru area to dark friable clays, and to red and strongly brown clays with occasional laterite horizons in Ol Kalou-Bahati area (Scott et al., 1971). In areas with high rainfall, the volcanic soils have developed dark-red friable clays and greyish brown mottled clays forming deep fertile soils, suitable for agriculture. In the plains of Ol' Bolossat and at Kinangop plateau, the soils are mainly dark grey to brown clay loam with dark clays of varying depths. The dark clays change to dark grey to black cracking clay developed over calcium carbonate or tuff in swampy places at Lake Ol' Bolossat and parts of Kinangop Plateau. The dark clays are seasonally water-logged making cultivation impossible in the rainy seasons.

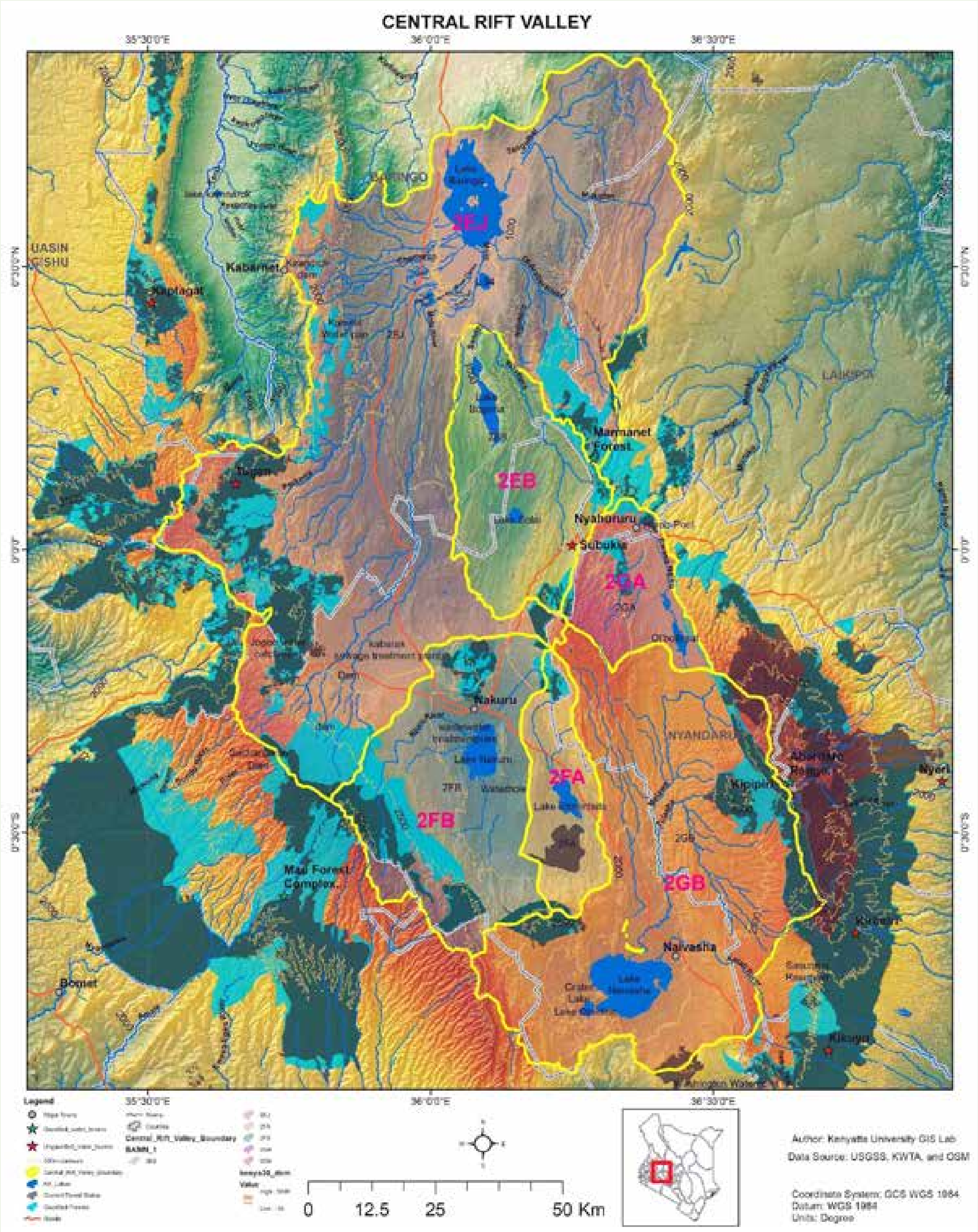


Figure 4: The topography at the crest of the Kenya Dome; the drainage into the lakes is influenced by the local fault platforms.

Volcanic soils derived from reworked pyroclastics and ashes cover most of the plains between volcanic cones and craters on the floor of the rift, along the axis of the Rift Valley. Around Longonot, and because of its latest eruption, the soils are mainly ashy and pumiceous. Around Menengai they are also pumiceous because of explosive eruption from Menengai prior to the latest lava flows in the caldera floor. As indicated by Scott et al. (1971), the Kedong, Kiwi, Ndabibi and Bahati plains, and the narrow grabens north of Olobanita, are in places covered by flood lacustrine deposits intercalated with, or covered by volcanic ashes, pyroclastics or alluvium. At the plains close to the escarpments the alluvial deposits are soils originating from volcanism on the floor of the rift and from talus material eroded from the escarpments.

1.3.1.4 **The Magadi Basin (South Rift)**

Evidence of the early tectonic style of the Rift Valley formation are seen in the broad half-graben depressions at Lake Turkana, and lakes Magadi/Natron in the Kenya Tertiary Rift Valley. The main lake, Magadi, is 104 km^2, 26 km long and 4 km wide and lies in a N-S elongated graben at the lowest point on the South Rift Valley of Kenya (603 m above sea level). The graben in which it lies was formed in the late Pliocene and the Pleistocene, the time of major rift faulting and volcanism that produced most of the volcanoes and the graben relief observed today in the entire Gregory Rift Valley. The Volcanoes of Suswa, El Esekut, Olorgesailie, Ol Doinyo Narok and Shompole mark the terrain of the Magadi Basin.

The Escarpments of the Gregory Rift were uplifted along a series of en echelon faults striking in a sinuous N-S trend marked by the Kikuyu Escarpment (eastern border fault) and the Nguruman Escarpments (western border fault) in the Magadi area. The faulting is complicated and forms a rift system rather than a simple rift valley. The floor of the rift in lake Magadi area, for example, is marked by grid faulting represented by numerous host-graben structures giving the terrain a blocky appearance of linear plateaus paralleling the escarpment and stepping down towards the axis of the rift valley. The Magadi Road crosses many of these fault structures. The average throw of these grid faults varies from 300–1500m and are the most recent movements in the area being mostly Holocene features. The amounts of displacements involved in the border faults of Kikuyu and Nguruman are enormous, about 1,800–3,050m.

The representation of the Rift Grid system in the Magadi Basin are well illustrated in the DEM of the area (Figure 5) and the fault systems in Kenya (Figure 6) which also show the location of the marble structures associated with foliations in the Precambrian terrain.

Lake Magadi is a soda lake and is a major foreign exchange earner to the country from the mining is trona, a compound of which 97% is sodium carbonate. The mining has been done since 1911 first by the Magadi Soda Company and now by Tata Chemicals. There is an even larger deposit of trona at Lake Natron in Tanzania which is south of lake Magadi. The trona is formed from leaching of the basic volcanic ash and lavas which collect at the lake through hot spring seepage and crystallize through high evaporation at the low altitude depression. Recent rise in levels of lakes and sedimentation are major concerns to the mining company.

Hot springs in Lake Magadi area provide evidence of the availability of geothermal resources in the area. At the lake, hot springs can be seen at the open waters around the border of the lake. Currently, geothermal energy is being sourced from Olkaria near Lake Naivasha.

In most cases, drainage sinks to the fault systems and is controlled by the faults influencing inflow into the lake both from the surface flow and from groundwater recharge. Deep percolation of waters from Lake Naivasha into this basin is believed to keep Lake Naivasha fresh. The basin has poor vegetation cover with the real Magadi Basin having 160 km^2 (1.93%) forest cover in a basin area of 8,299 km^2. The lake is rich in trona, soda ash(Plate 1), for which it is mined. The rest of the Magadi Basin area drains to Ewaso Narok Flood Plain and into the Lake Natron through groundwater seepage.

Plate 1: Trona (soda ash) covered Lake Magadi sits in a fault bound trough in an area poorly covered by vegetation and with very low rainfall. Recharge is through underground springs.

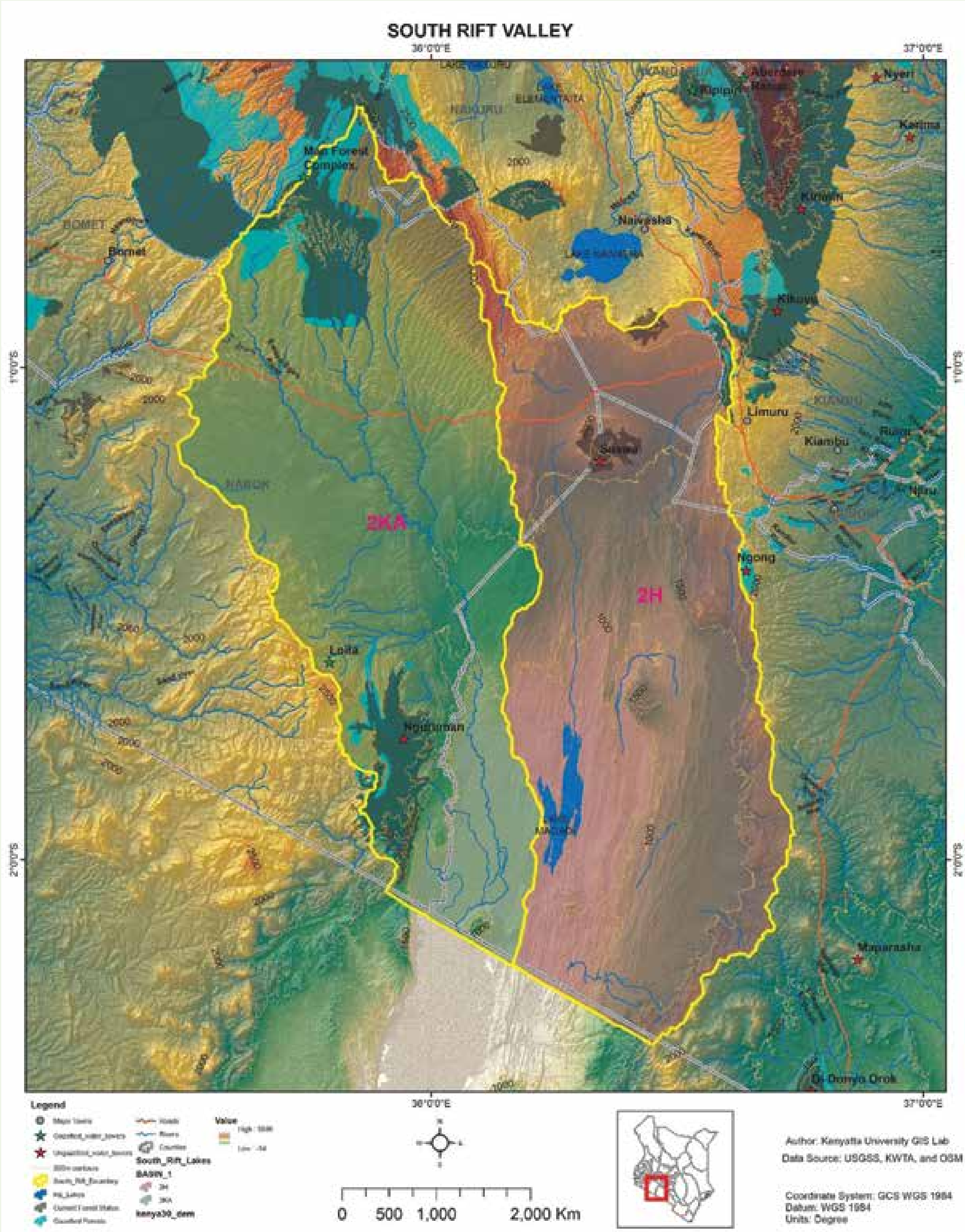


Figure 5: DEM of Lake Magadi Basin shown the two major watershed in the area; note the north-south grid faulting.

The basin has poor vegetation cover with the real Magadi Basin having 160 Km^2 (1.93%) forest cover in a basin area of 8,299 Km^2

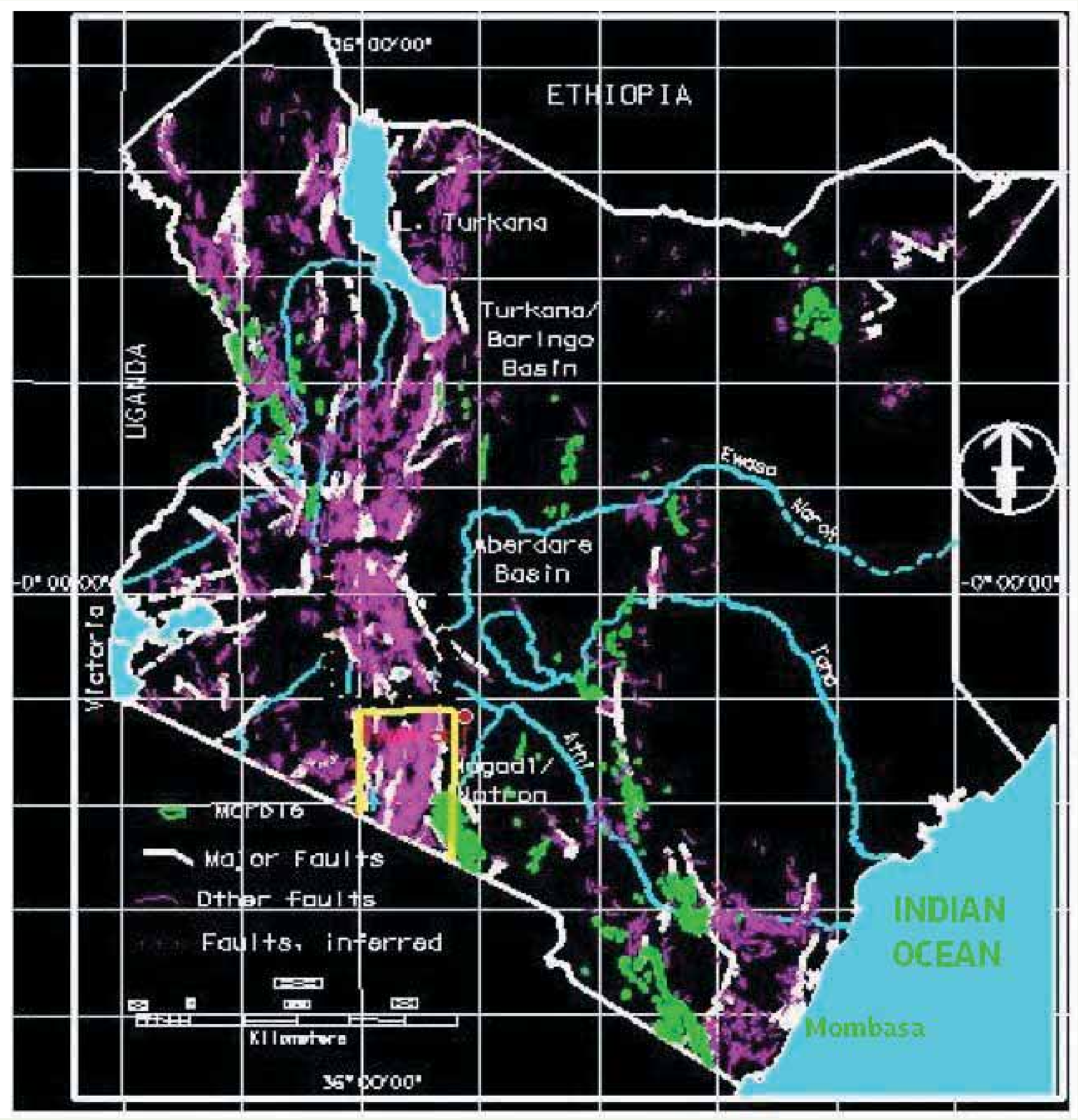


Figure 6: The Fault Regimes in Kenya.

2 Impact Assessment and Key Findings

2.1 Population and Human Settlement

2.1.1 Lake Turkana and its Catchment

Changes in Lake Turkana are documented in the series of natural-colour images taken by the Landsat series of satellites in 2010, 2014 and 2020. Delineation of the water area of the lake showed that the lake increased in area by 779.59 km^2, flooding all the low-lying coastal areas and the grasses therein. The increase in area of the lake is about 10.4%. The affected land and the extent of the impacts are shown on the image (Figure 7) and the map (Figure 8). Water backflows within Lake Turkana and its surrounding areas rendered the settlements uninhabitable with several homes, institutions, health facilities and worship centres marooned. *30,186 people* owning Small Business Enterprises (SMEs) were reported to have been affected by flooding waters *(Plate 2); 64 boats were destroyed,* and *19 human lives were lost following attacks by crocodiles*. The impacts of flooding backflow waters had further initiated differential settlement. This was observed at *St. Kelvin school's infrastructure* which had been submerged, with evidence of other submerged structures up to 3m above ground traced from remnants of flooding water marks on the walls *(Plate 3)*. *23 health facilities* and *30 worship centres* were affected. A number of buildings also exhibited diagonal cracks on the walls.

Plate 2: The chief of Longech Village at Fergusson bay explaining challenges they are facing due to rising waters.

Plate 3: The height of flood waters that befell St. Kelvin's School, Lodwar Town. The waters were observed at 3m above ground level.

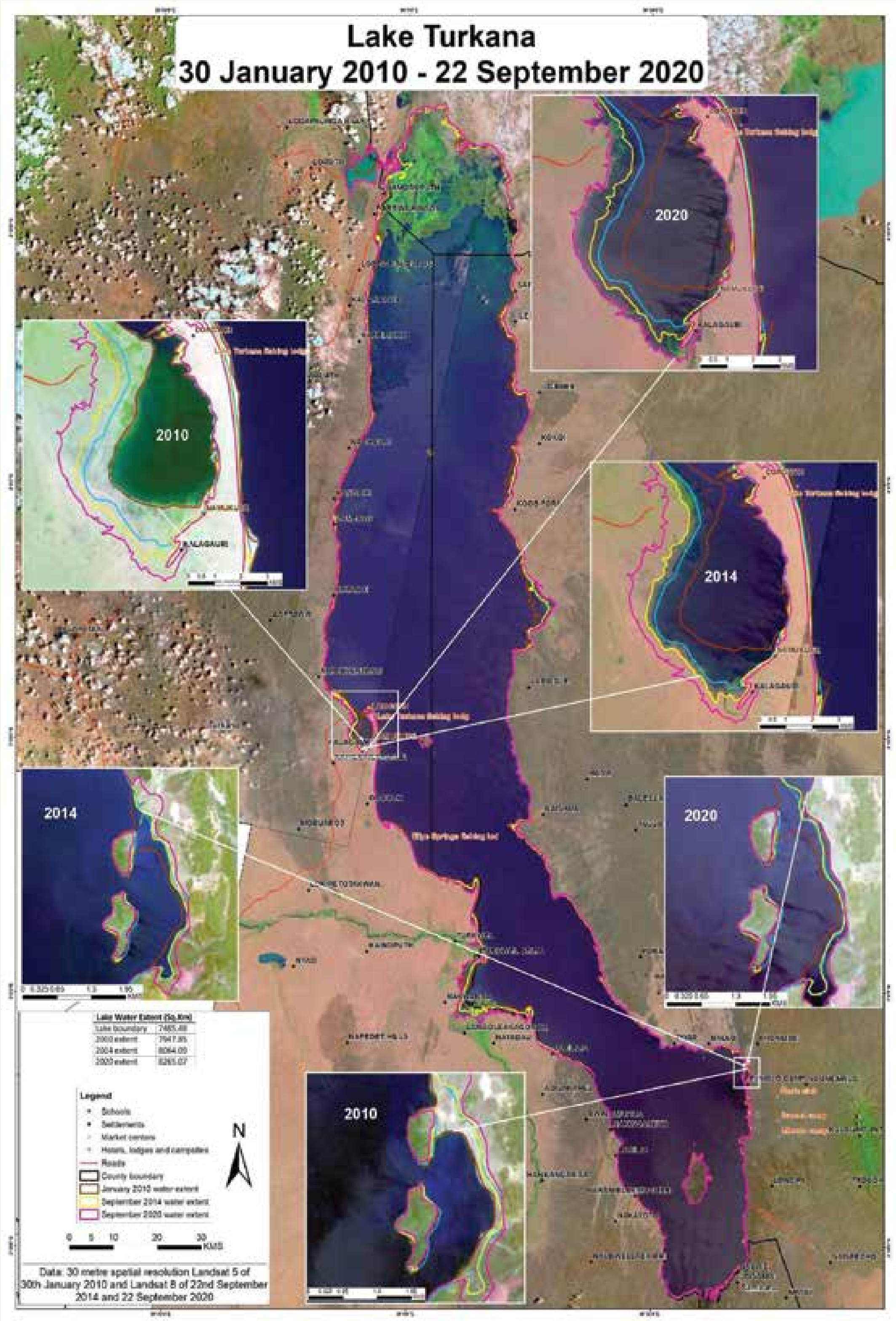


Figure 7: Landsat image of Lake Turkana (September 2020) showing the extent of flooding from the lake level and zoom-in areas of the lake level rise.

The water levels recorded in 2020 are the highest Lake Turkana has ever registered in recent years. The flooding submerged approximately 779.6 km^2 of land around the lake, which is usually occupied by human settlements. This has resulted in loss of properties and displacement of a large population which has been forced to move to higher grounds. Figure 8 below shows the affected area, marked in deep blue colour.

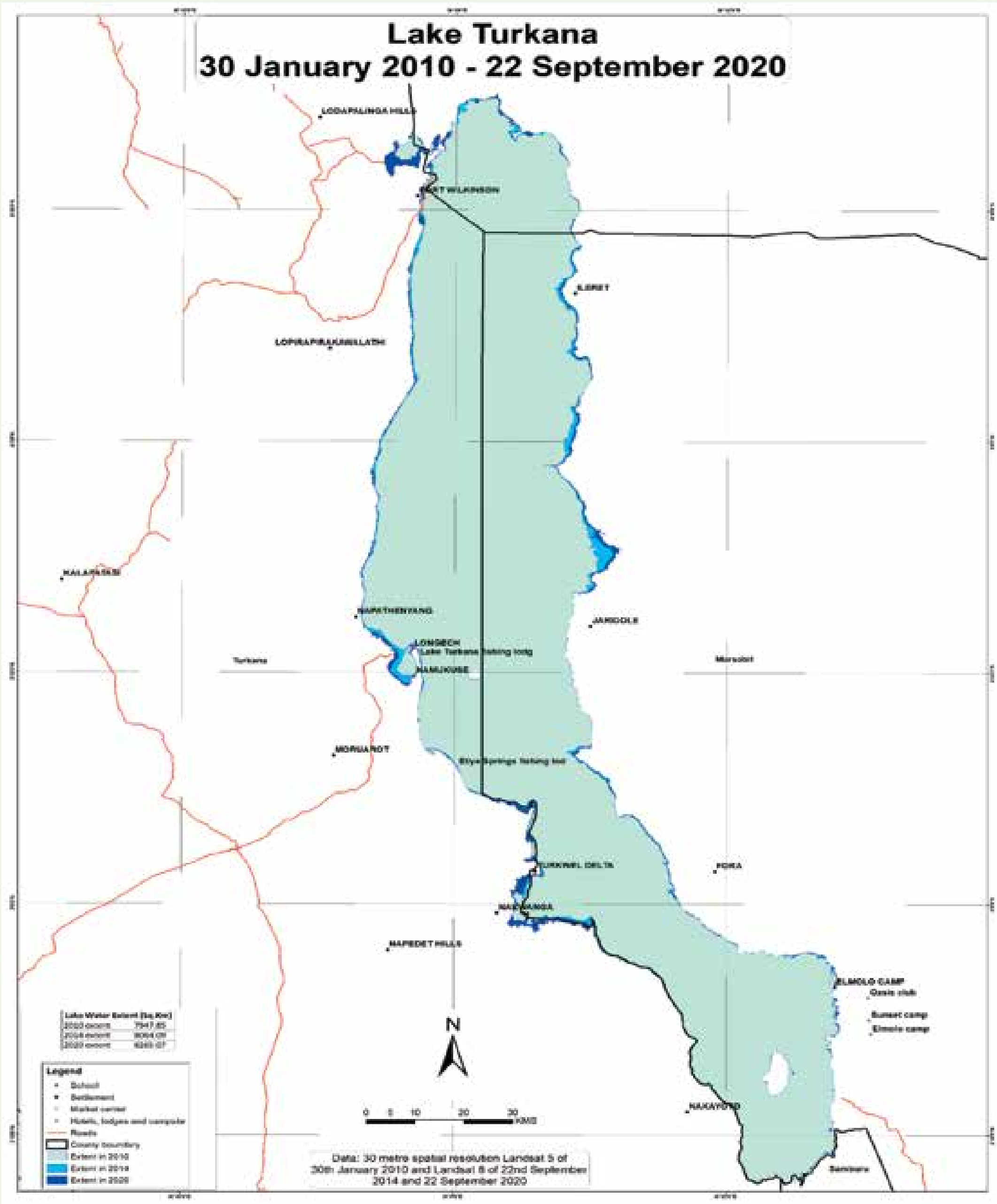


Figure 8: Map of Lake Turkana showing the flood areas around the lake; 779.6 km^2 of Land is affected.

On *Water, Sanitation and Hygiene,* the assessment revealed a dejected state, where the affected populations are unable to access clean safe drinking water. At least *32 boreholes* were reported to have been destroyed and/or submerged, including *9 boreholes supplying water to Lodwar town*. The *water tanks at Nadoto and Lokwar boreholes* were at risk of being submerged. Many people from various villages like Namakat were compelled to use river water which is extremely unsafe for domestic purposes. The floods had also submerged most of the sanitation facilities causing contamination of both surface and shallow ground water sources. This exposed communities to an upsurge of waterborne diseases such as diarrhoea, cholera and typhoid, since the water they consumed was neither treated nor disinfected.

Agro-pastoralism and riverine economy was also affected by the ravaging floods, with *livestock affected estimated at 3,479,126*. The livelihood of *12,392 people* who depend on 2 submerged irrigation schemes (Ngimuria and Nariokotome Mission Gardens) were disrupted. In addition, *50 Beach Management Units (BMUs)* were reported to have been destroyed. This had ripple effects on fishing in terms of marketing of the fish, on movement between the peninsula and Kalokol on the mainland and on access to health services, especially for the children *(Plate 4)*.

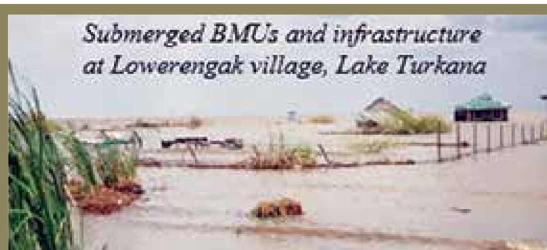


Plate 4: Submerged Longech Village at Fergusson bay and BMUs at Lowerengak Village around Lake Turkana basin.

Following high dissipation of wave energy along the coastline, property worth millions of shillings have been destroyed. For instance, losses at Eliye Springs Resort were estimated at 7 million shillings. Submersion of the beaches has interfered with the rich cultural heritage of the communities around the Lake, for example, *47 grave sites in Longech island and hundreds of graves in El Molo Village* have been submerged *(Plate 5)*. Accordingly, significant cultural sites may continue to be lost, such as the fossil sites along the riverine environment.


Plate 5: Submerged graves at Longech Village, Fergusson Bay (Turkana County) and Layeni Village, El Molo Bay, (Marsabit County) respectively, the lake Turkana Level Rise has been of a cultural heritage challenge.

The displacement of people at Fergusson Bay, Ileret and El Molo Bay (Plate 6) has left many with no settlement, a challenge that is compounded by the fact that most of the land in the surrounding areas is privately owned. At Eliye Springs, the landowners now in their 100th year of land lease, and whose business places have been negatively affected by the flooding, are not allowed to renew their licenses. This has created a legal battle for the investors. Communities interviewed indicated that they had received notifications from the County Government through their Ward Administrators and Area Chiefs, advising them of the expected overflow of Lake Turkana. They also indicated that they understood the potential risks involved and were willing to relocate to higher ground for safety purposes. They further indicated that they have been sharing such advisory with other members of the community.

Plate 6: Evidence of flood impacts from the rising water levels in the lakes affecting infrastructures as far north as Ileret (Left business facility) and South as Loinyangalani (right refrigeration house) both in Marsabit.

2.1.2 **Effects of Rising Water Levels in Turkwel Gorge Dam**

The extent of the rising water levels Turkwel Gorge Dam is shown on the image in figure 9 and map in figure 10. Turkwel Gorge Dam that was commissioned in 1991 reached its highest historical level during this flooding period. The rising water has had a number of impacts on the population, with 5000 households (30,000 people) displaced, 13 schools with a population of 2700 affected, 4 worship centres destroyed, and 56 lives claimed by mudslides in Sebit area (Plate 7).

Plate 7: Evidence of landslide hazard at Sebit Bridge at the confluence with Muruny River and at the Sebit stream.

Plate 8: Community engagement forum at Morkorso village living around Turkwel Gorge Dam in West Pokot County.

The fisheries sector was impacted both positively and negatively. Reported negative impacts include: 13 villages affected, 11 tilapia breeding sites destroyed, 13 rocky islands submerged, nine (9) boats destroyed, and hundreds of people living around the dam displaced. Morkorso village where the scoping team engaged the communities in a focused group discussion is an example *(Plate 8)*. The rising water from Turkwel Gorge Dam has also led to loss of grazing land within the riparian areas. It was reported that approximately 6,000 acres of grazing land had been flooded *(Plate 9)* whilst at least 61 goats were reported to have been eaten by crocodiles during the month of September 2020 alone. This illustrates a potential wildlife-livestock conflict.

Plate 9: Submerged Grazing lands around Turkwel Gorge Dam area.

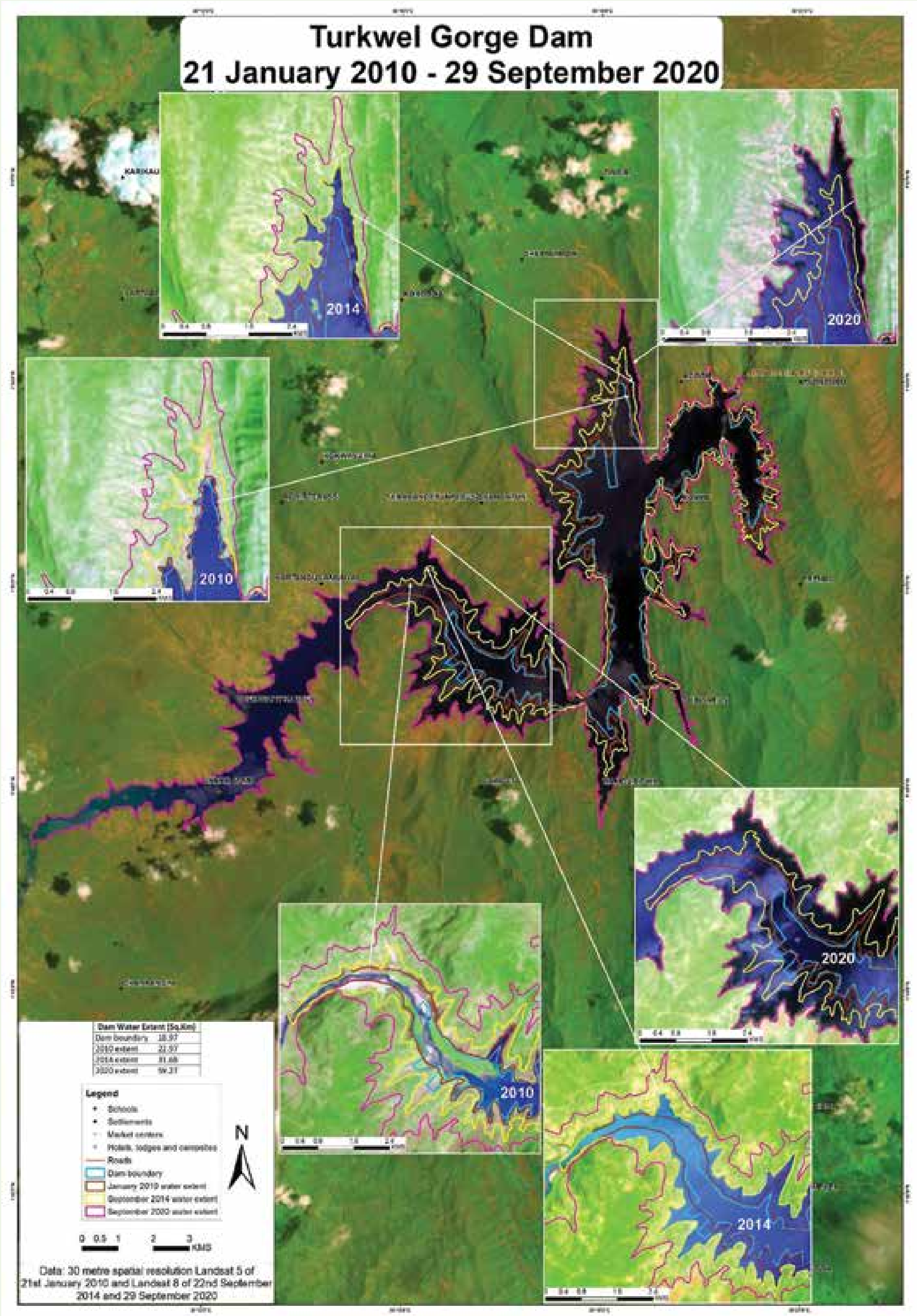


Figure 9: Turkwel Gorge Dam level rise drastically extended its flooded area in the period under observation from 23 km² in 2010 to 59 km² in 2020 threatening to spill over the dam wall.

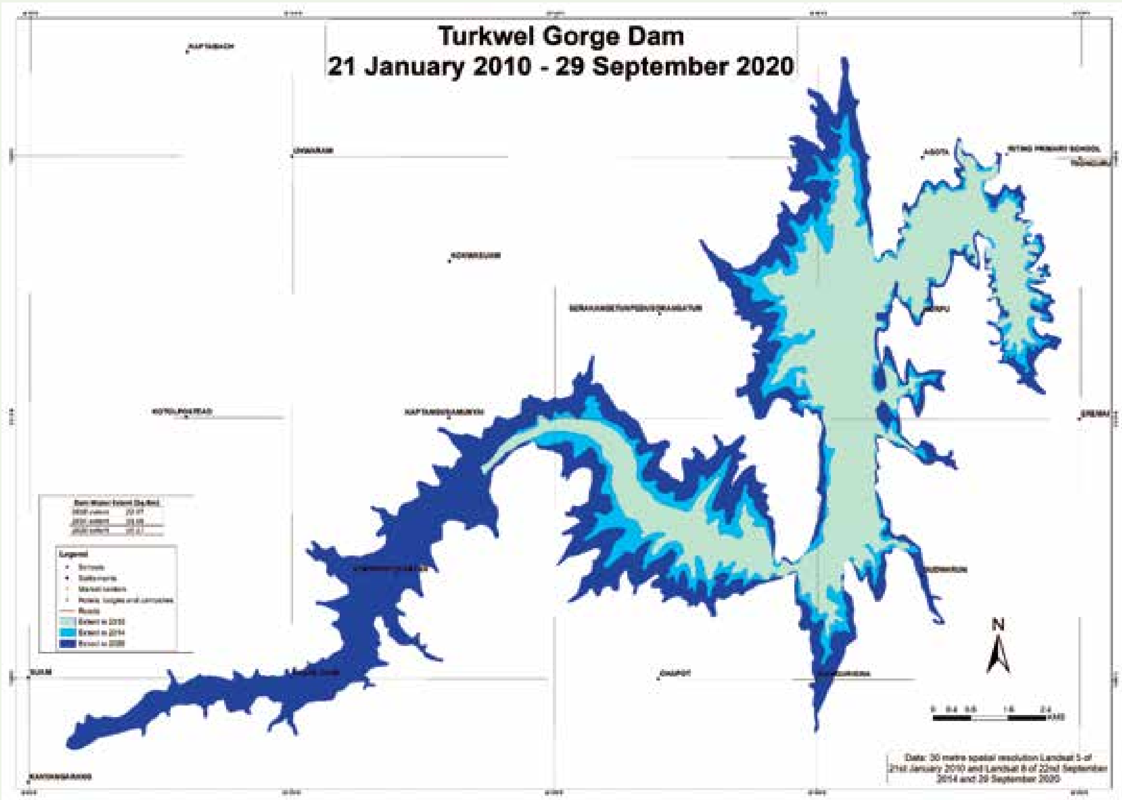


Figure 10: Turkwel Gorge Dam flooding affected at least 13 villages and cut off a number of schools marooning them at the hill spurs as the valleys filled up with the rising waters.

Water, sanitation and health facilities have equally been affected, with 16 boreholes and 3 health facilities submerged. On matters of land compensation, various families in Morkorso village were compensated before the building of the Turkwel Gorge Dam. However, land within a riparian area cannot be compensated since it is part of the conservation area. The Environmental Management and Coordination Act, EMCA, (2015) is clear on riparian land being a public property.

Human-wildlife conflicts were also reported in the area, one case of a crocodile attack being an example. Moreover, there has been increased tension between Pokots and Turkanas due to loss of grazing lands and lack of awareness of the dam operational mechanisms. Community sensitization on dam operations is critical.

2.1.3 Lake Baringo Basin Area

Over the years, the rising water levels in Lake Baringo have claimed 139.98 km^2 of riparian land as illustrated in Figure 11 and Figure 12. Communities Further, approximately 3,087 households of communities living around the lake have also been immensely affected.

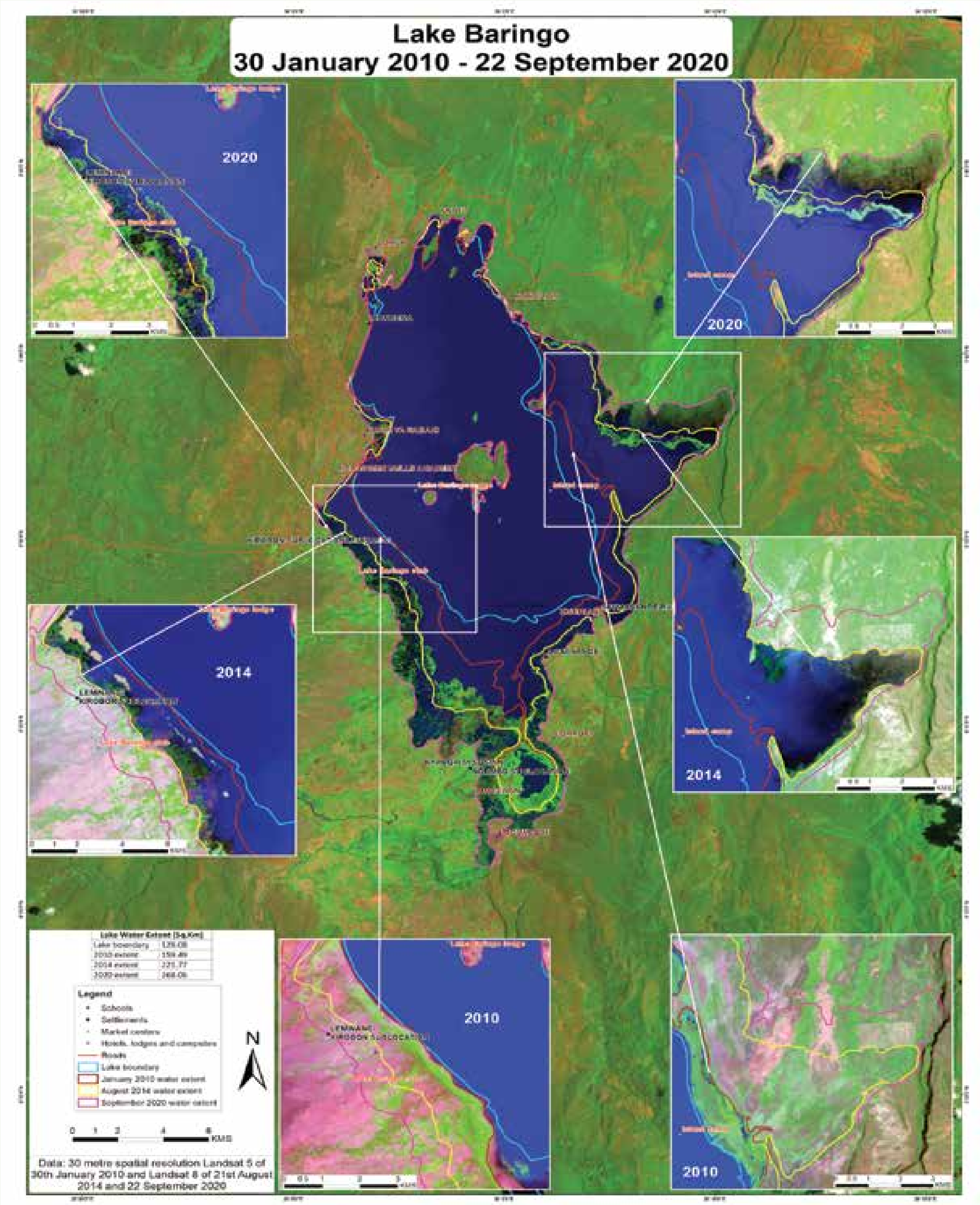


Figure 11: Image of Lake Baringo showing an extensive submerged area around the lake.

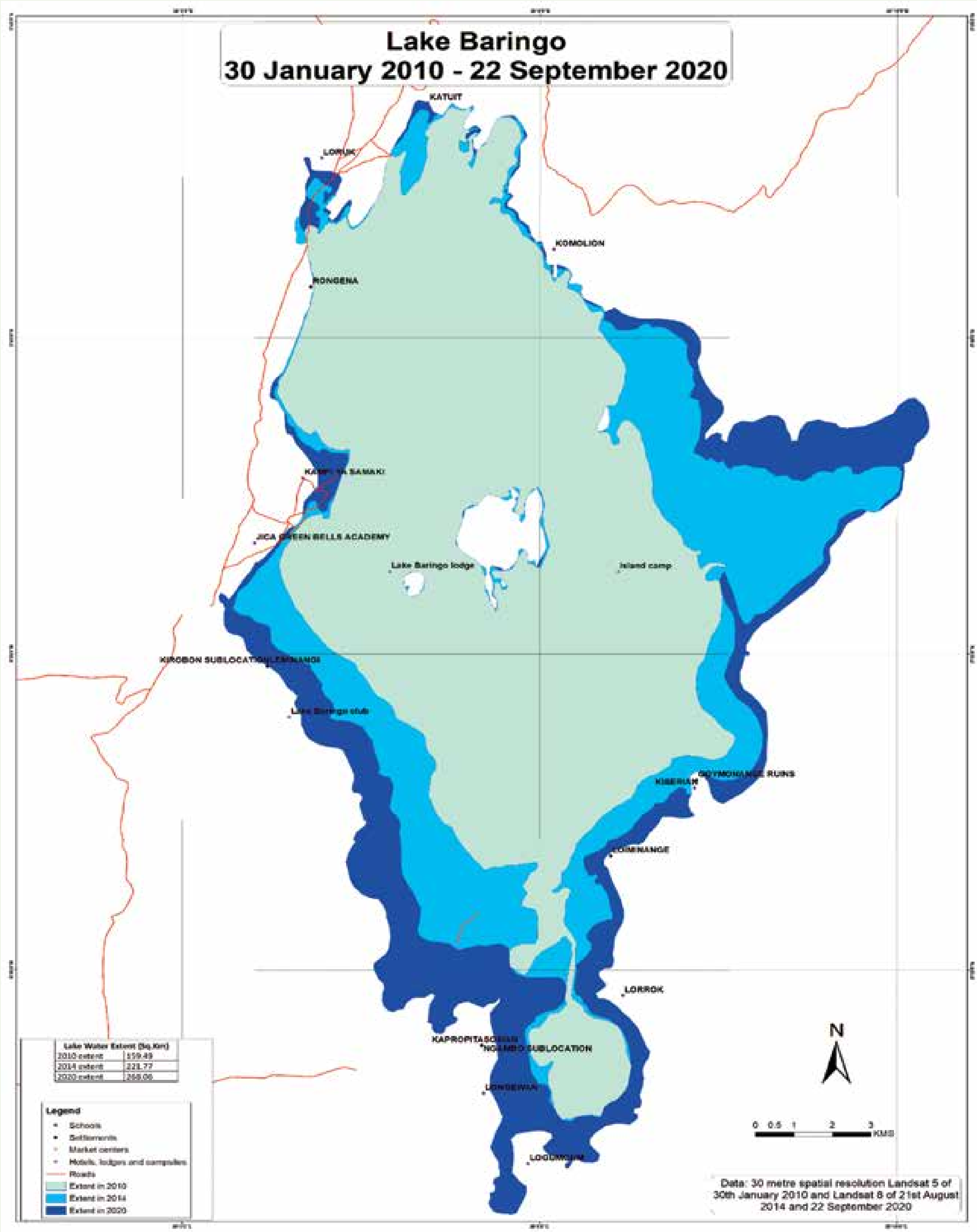


Figure 12: 108.57 km² of land in Lake Baringo has been submerged since 2010, the lake merging with Lake 94.

Lake Baringo was one of the worst affected lakes in the Rift Valley flooding an estimated area of 108.57 km^2. The flooding displaced several settlements bordering the lake particularly the southern and the western parts.

The flooding has caused major disturbances including the destruction and loss of property, displacement of communities, and loss of animal and human lives. Many have been relocating their homes to higher grounds every few months as the lake rises. Some households have rebuilt their homes up to 5 times since this began. Further, the rising water levels have disrupted communities' livelihoods by destroying and sweeping away the little available possessions and restricting access to natural resources and even markets. Several shopping centers have been submerged, for example Loruk (Plate 10), and villagers therefore have to walk long distances of about 5 km to find a shop, or they have to row canoes across the lake, for instance to *Kampi ya Samaki*, which is about 20 km away. Grazing fields and farms have been submerged and fishing is harder since the fish hide in the roots of trees where the water has risen to. There are a few alternative sources of livelihood, but these have not been explored due to lack of support.

Plate 10: Submerged shopping facilities, electricity poles and road infrastructure in Loruk.

The submersion of 6 health facilities; Loruk, Kambi Samaki, Loboi, Salabani, Ng'ambo and Ol Kokwe Island has hindered access to medical services for people living in the area. The community expressed the need for emergency health services, citing lack of basic drugs in the few accessible facilities. There is also a need to extend psychosocial support to the affected population. Several residents expressed fear that the ongoing displacements impede the rights of women and as such, increase the risks and incidences of Sexual and Gender-Based Violence (SGBV).

The mission noted that the affected populations are at risk of contracting water-borne diseases including malaria, cholera, typhoid, dysentery and amoeba as well respiratory infections because of the cold. The living conditions are poor; the affected populations live in geographically scattered areas with little socio-economic means. Women face Sexual and Reproductive Health (SRH) challenges. Through direct observations and key informant interviews among women and men Kiwanja Ndege IDP camp, for example, it was evident that there were high rates of unmet needs among women in their reproductive age. Some of the health challenges recorded include a high risk of unwanted pregnancies, STDs, complications due to pregnancy, menstruation disorders, and maternal mortality. The inaccessibility of antenatal clinics also forced many women to consider home delivery, which poses a greater risk of birth related complications and neonatal death.

Of those affected by these floods, persons living with disabilities (PWDs) and the elderly face more challenges. Clinical assessments on the nature of disability during the intervention will be very critical and paramount to inform further support.

On psychosocial impacts, scores of residents were under severe stress from the losses they have incurred due to the rising waters. Owners of once booming businesses like Lake Bogoria Curio, Lake Baringo Club and Restaurant, Papyrus Inn, and Soi Lodge that were accommodating middle-income guests and tourists are traumatised, having lost their main source of livelihoods. Plate 11 shows submerged facilities of Lake Baringo Club and Restaurant.

Plate 11: Submerged Lake Baringo Club Lodge facilities.

There is a premise for *human conflict* in the area, as the villagers move closer to the lake and compete for pastoral land. Furthermore, the communities of lowlands in Baringo South are moving closer to the hills of the neighbouring Pokot, awakening historical grievances. In addition, hippos and crocodiles have since moved closer to the villages and are threatening the inhabitants and their livestock, a potential to fuel *human-wildlife conflict*. One of the ways to prevent further conflicts would be to establish of a new high-water mark, delineating the riparian land and safeguarding it for further use in case of continued water rise.

Several *legal issues* are also bound to arise, mainly concerning land management issues: mixed tenure, acquisition of land ownership documents, securing land and mixed land uses. For instance, in Loboi and Kambi Samaki areas, where most of the land has been submerged and where there is a need to re-determine riparian borders, there is a possibility that litigation issues regarding re-settlement and compensation will arise.

2.1.4 Impacts on Lake Bogoria Basin

Lake Bogoria is a major tourist destination. The lake is famous for its boiling springs and millions of flamingos. With the rising water levels, however, most of the hot springs have been submerged and all geysers have been suppressed as can be seen in Plate 12. The population of flamingos has also reduced due to the destruction of their algal feeding areas. Only tens of thousands now remain in the lake with most suffering injury and some dying in the process of seeking wading areas among the submerged thorny trees.

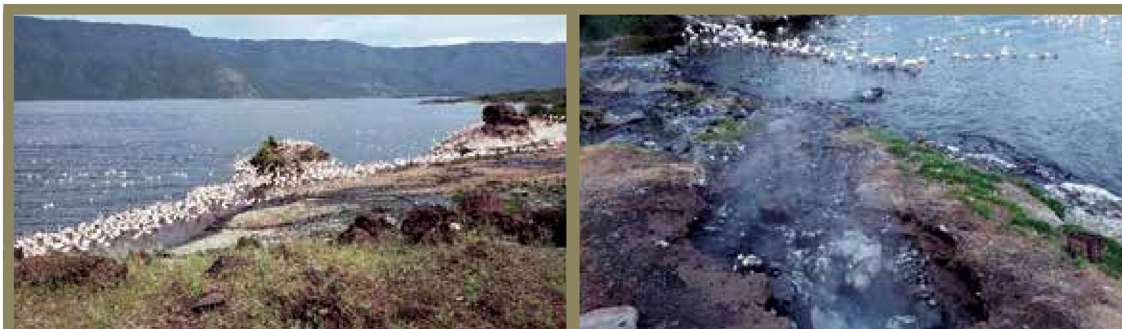


Plate 12: Submerged hot springs and geysers in Lake Baringo; seen are also a very low population of flamingos.

The main feeder rivers to Bogoria are Waseges, Sandai and Loboi flowing in from the north of the lake and Emsos springs flowing in from the south. As the lake is a closed basin in a deep graben, the rising lake is flooding towards the north and has submerged the main gate (Plate 13) and the surrounding villages that had settled in the plains there. The flood waters have rendered the surrounding settlements, schools, homes and shopping centres submerged. Most of those affected have sought refuge in higher grounds nearby while others are being hosted by relatives and neighbours. The flood is known to have contaminated several water points and sunk/submerged several latrines putting the area at high risk of water-borne diseases outbreak.

Plate 13: Lake Bogoria main gate in disuse after flood water intrusion from the rising lake and a flow back of River Waseges.

The areas affected by the rising waters in Lake Bogoria are shown in Figure 13 and 14. 2 high-resolution images obtained from Google Earth images, presented in Figure 15, show the extent of the flooding and the impacts on riparian land and infrastructure on two separate time periods, 10 September 2010 and 15 January 2021. By the latter date, almost the entire circuit road around the western shore of the lake had been submerged occasioning relocation and definition of a new route to facilitate access to the park.

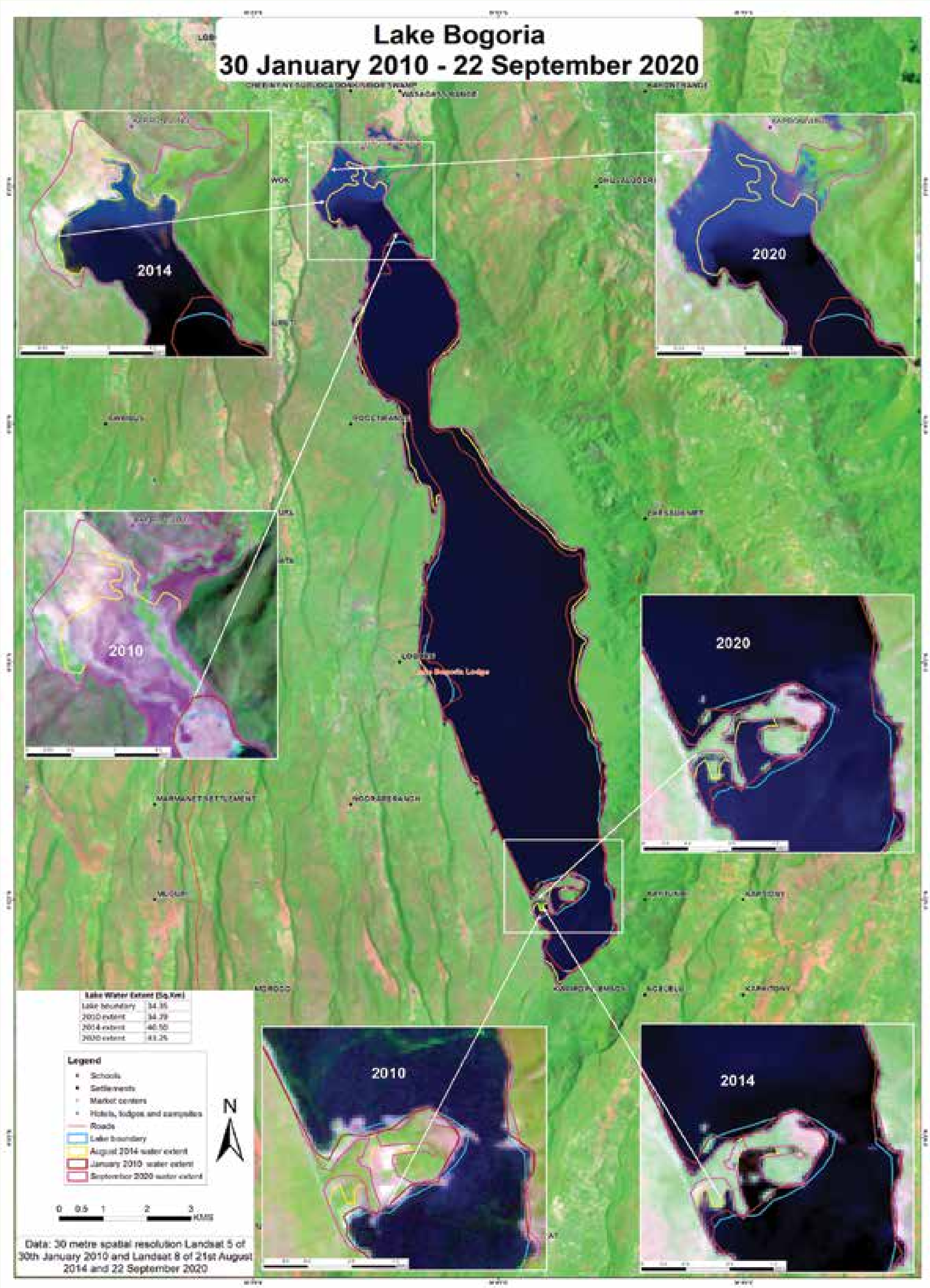


Figure 13: Image map illustrating the areas most affected by the rising Lake Bogoria.

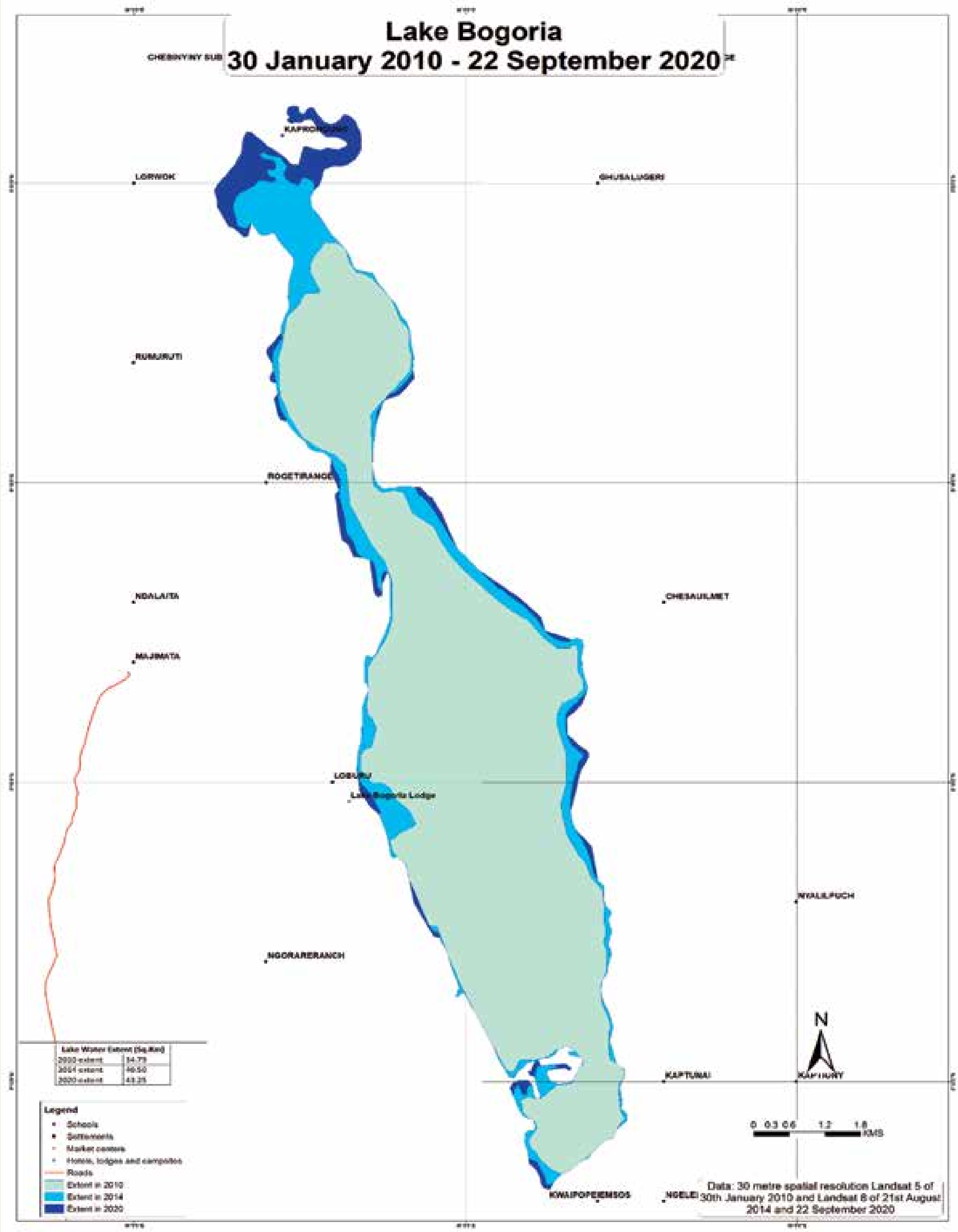


Figure 14: Map of Lake Bogoria showing the areas most affected by the rising lake.

Figure 15: Google Earth image extract showing the status of the Northern end of Lake Bogoria on 10th Sept. 2010 compared to the status on 15th January 2021 clearly showing the location of the submerged roads and the position of the relocated road

2.1.5 Lake Solai

At Lake Solai, 7.87 km^2 or 137.11% of the lake area was affected by the rising water levels (Figure 16 and Figure 17). A number of socio-economic issues that arose in relation to rising lake water included 86 landowners who lost over 2,625acres of land to flooding. These include: Solai Roiyobo Farm (2,000 acre), Kampi Ndege Scheme (20 acres), Kasururei Farm (200 acres), Kale Farm (126acres), Arus Farm (20 acres) and Tuiyotich Farm (260 acres). Gradual displacement of families in the area was evident. The loss of public facilities like a school playground (Ngendaptich primary) portends the danger of drowning of school children and other inhabitants.

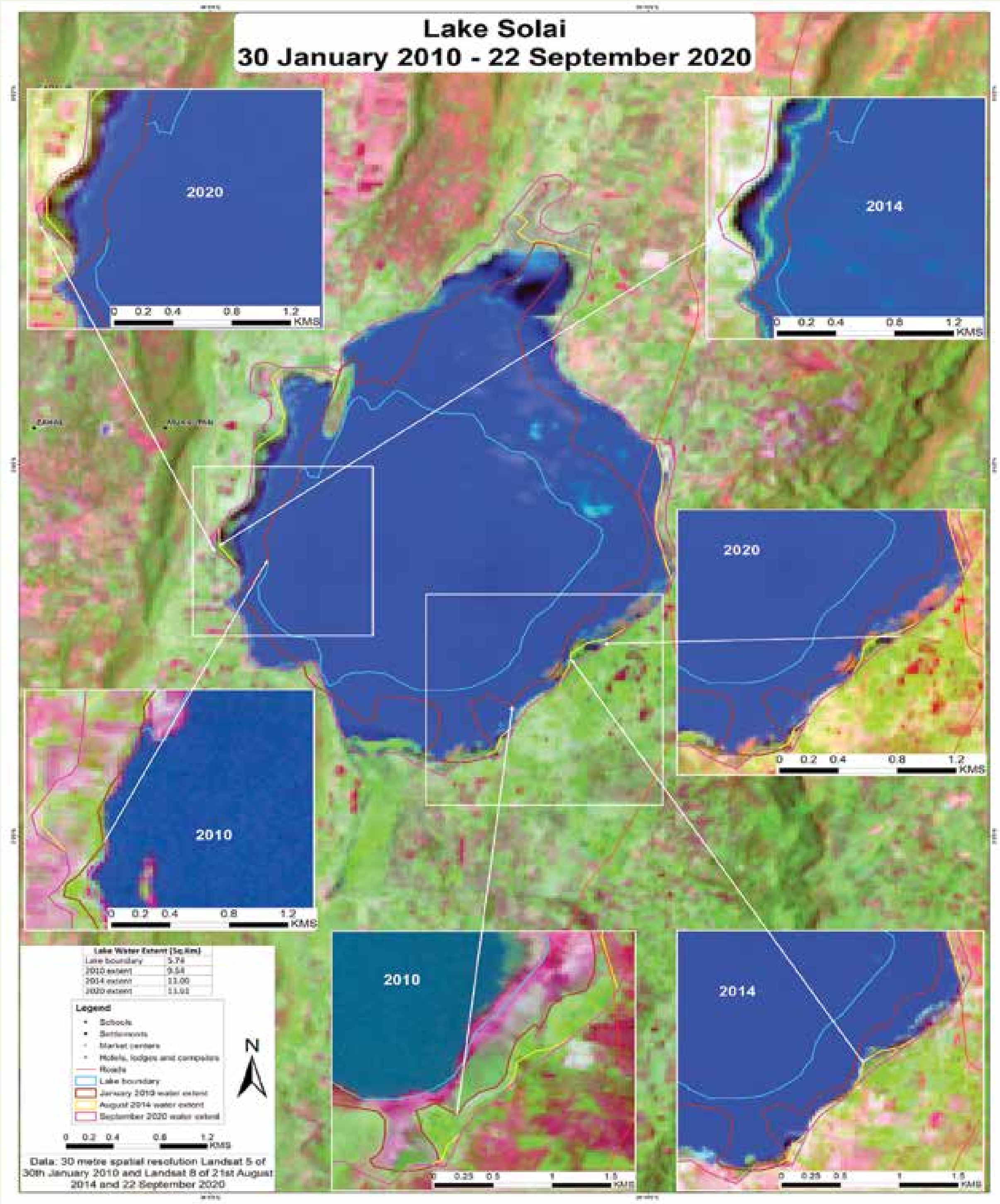


Figure 16: Image of extent of Flooding of Lake Solai

Farming activities around Lake Solai were also affected after most of the farmland was submerged, leading to loss of crops (Figure 17). Some settlements in these areas were also affected.

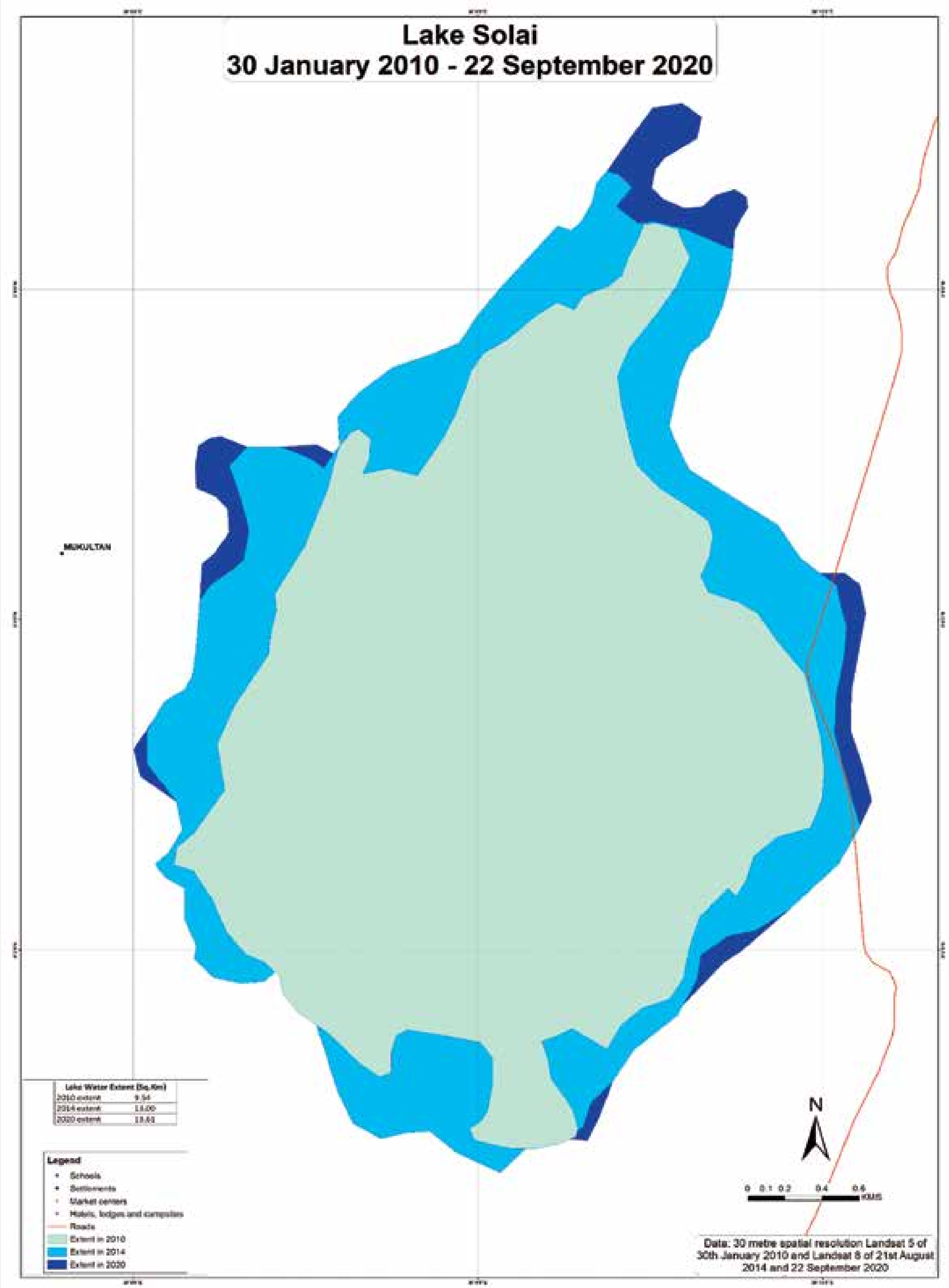


Figure 17: Map of extent of Flooding of Lake Solai.

Livelihoods were also affected in that some grazing lands were lost and some bird species on the lake that usually earned revenue to both governments and the community were affected.

Should riparian areas be demarcated afresh, those who presently legally own acres of land around the lake will definitely demand compensation, brewing legal issues.

2.1.6 Lake Ol' Bolossat

Following rising waters, the surface area of Lake Ol' Bolossat increased from 18.2 km^2 to 52.16 km^2, an increase of 33.96 km^2 (186.59%) as shown in Figure 18 and Figure 19. This led to loss of property and displacement of a large population. Socio-economic impacts relating to the rise of Lake Ol' Bolossat have largely been felt by the hotel and tourism sector. The lake was recently identified as Kenya's 61st Important Bird Area (County government of Nyandarua, 2018). Rising water levels have led to job losses due to decreased tourism activity.

On Security matters, Hippos on Lake Ol' Bolossat have posed a major concern to the safety of local communities. There have been cases of injuries and fatalities as a result of hippo attacks.

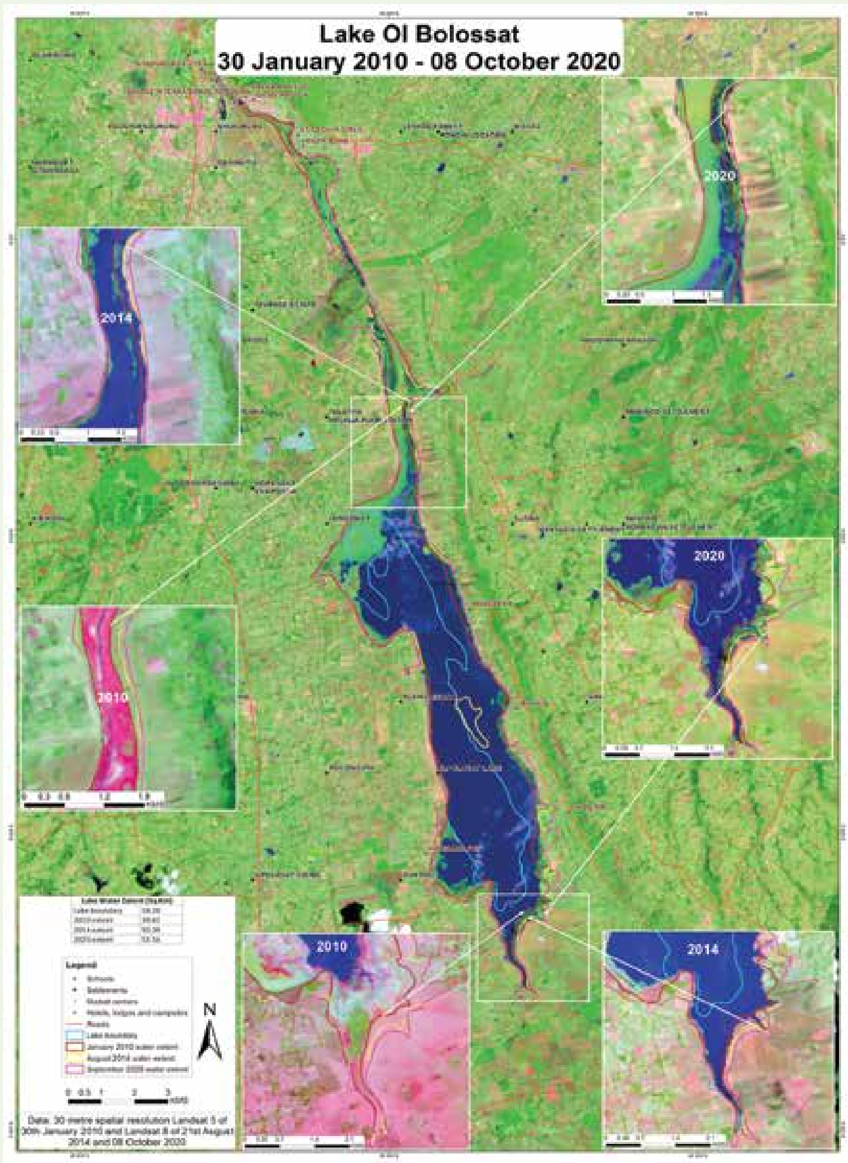


Figure 18: Lake Ol' Bolossat draining north-ward to exit out of the rift valley at Thomsons' Falls at Nyahururu showed flooding of 33.96 Km^2 of land.

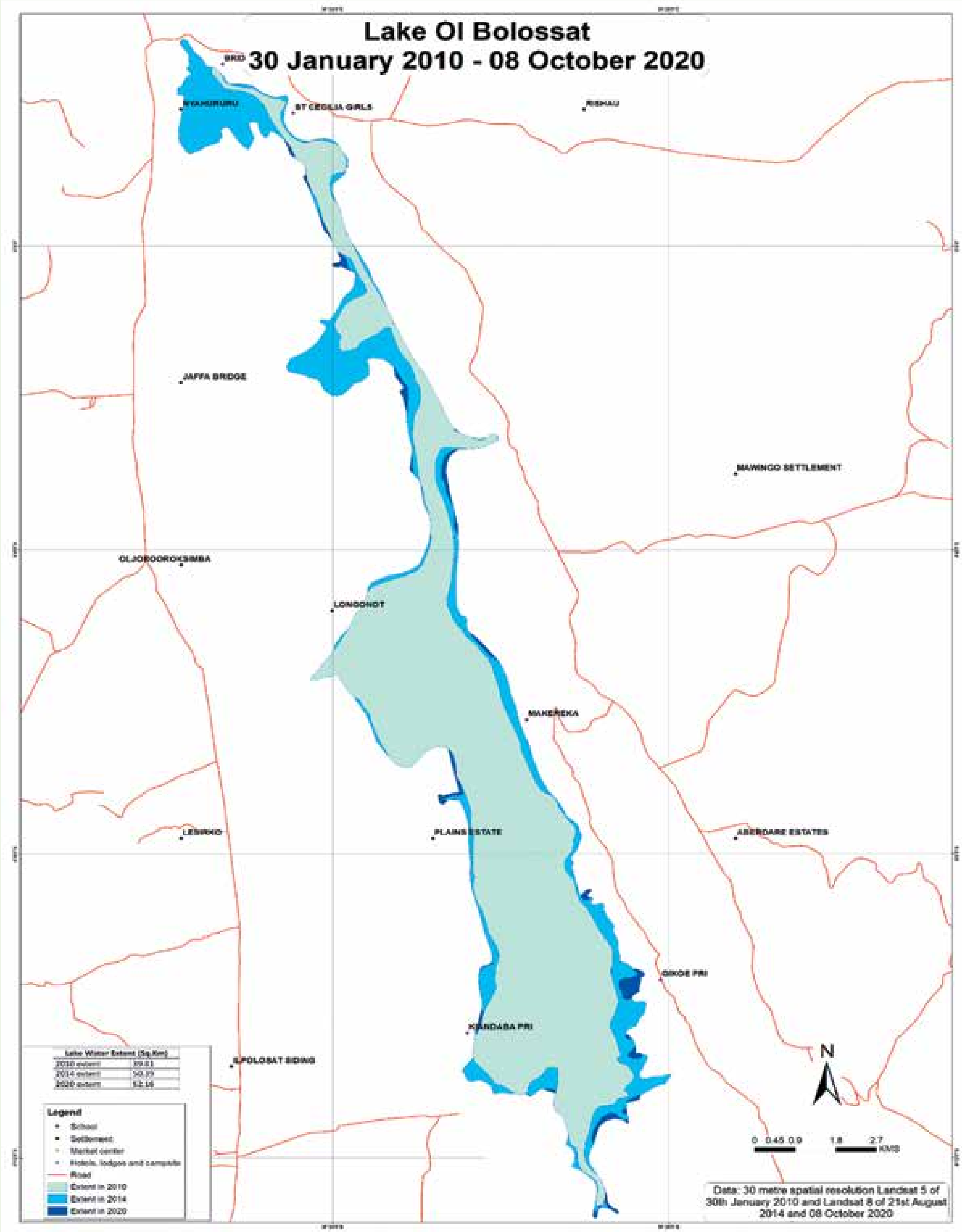


Figure 19: Extent of flooding of Lake Ol' Bolossat.

2.1.7 Lake Nakuru

Lake Nakuru rose from 40.4 km^2 to 68.18 km^2, a difference of 28.14 km^2 or 70.28% (Figure 20). The rising levels of the lake coincide with the increase in rainfall in the catchment areas, with sharp increases in the surface area observed in 2014 and 2020 (Figure 21). In 2020, at least 677 families were affected, including: 325 households at Barut East sub-location of Barut Ward, and 352 households in Mwariki area. The Nakuru sewerage works were also submerged (Plate 14). In Parkview sub-location in Barut location, about 70 acres of land has been submerged too.

The rising water levels have also affected livelihoods through loss of grazing and farm and crop land. Reports of attacks by wild animals like snakes have also been made. Additionally, it was observed that the affected communities are at high risk of contracting waterborne diseases due to the submersion of public utilities like sewage treatment plants and other sanitation units.

On social and cultural factors, the scoping team noted that a number of the affected community members have experienced trauma and psychosocial problems. Many of them are affected by depression which has been caused by the effects of displacement, insecurity, and economic losses incurred from disruption of livelihoods, unemployment and closure of businesses.

It was observed that the affected communities are at **high risk** of **contracting waterborne diseases** due to the submersion of **public utilities** like sewage treatment plants and other sanitation units

Plate 14: Rising Lake Nakuru crossing over the park boundary fence to the sewerage works and Mwiriki village in Barut.

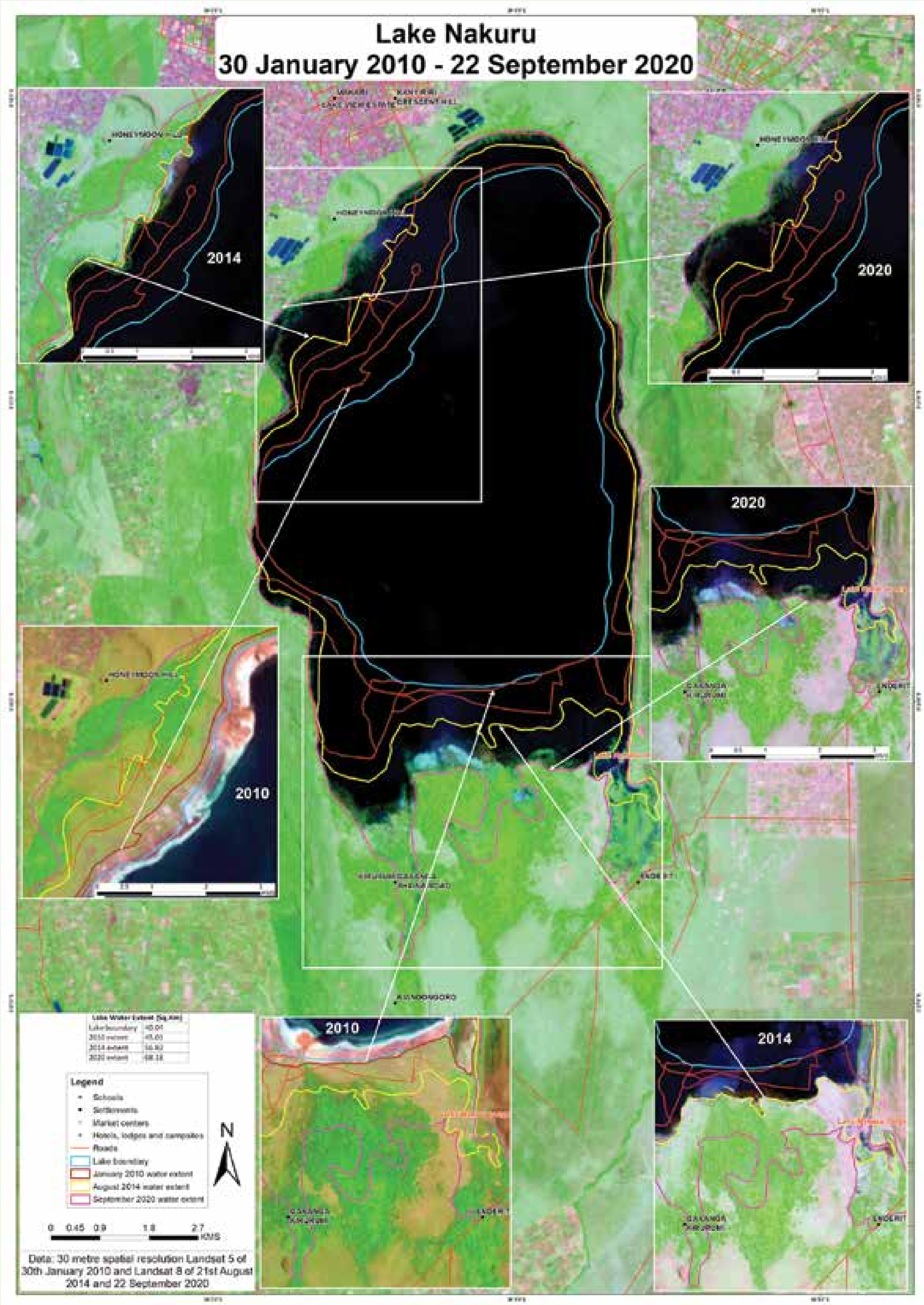


Figure 20: Lake Nakuru showing an entire circuit road system that is submerged.

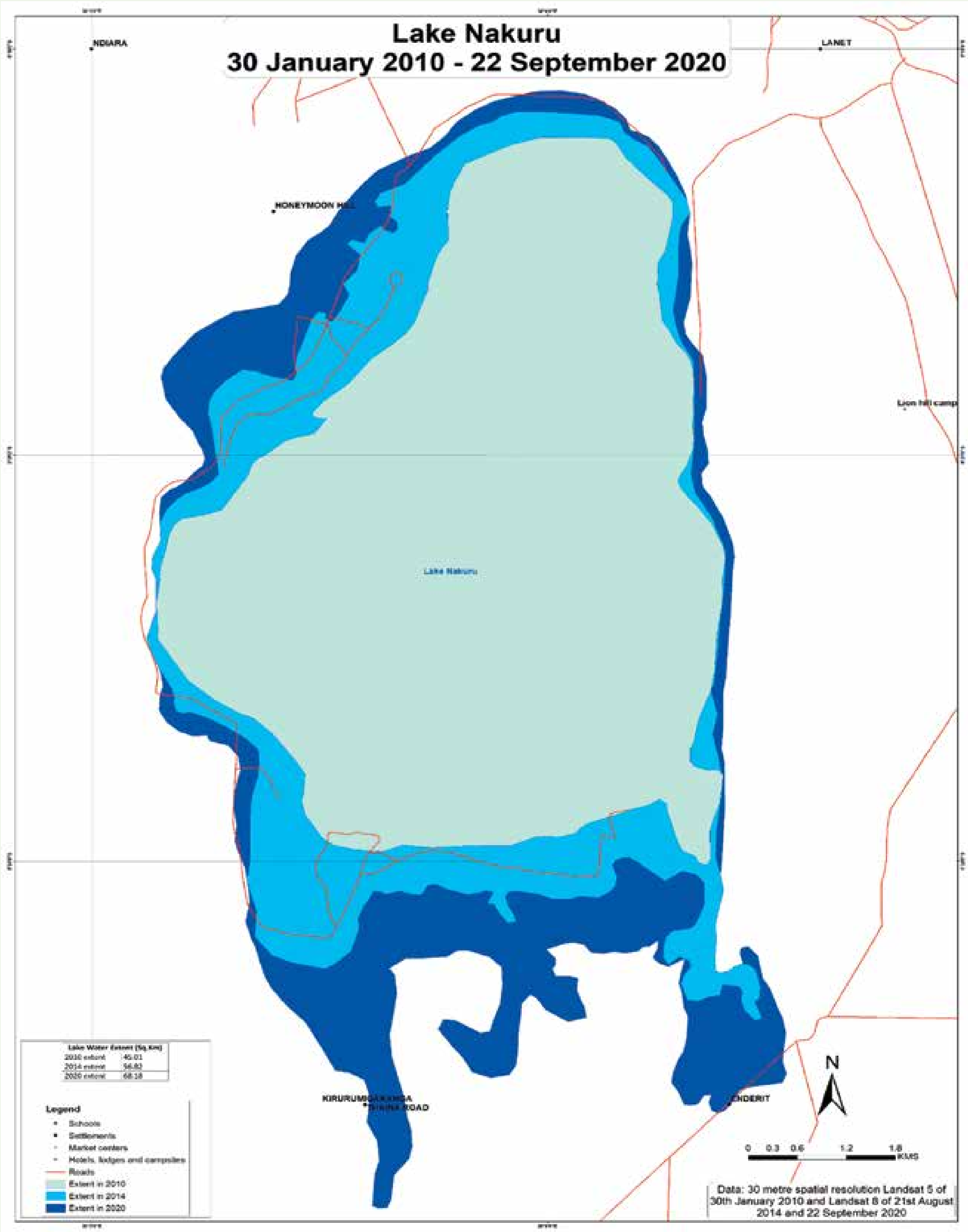


Figure 21: Map of Lake Nakuru showing the flood extent.

At KWS and Nakuru National Park, the main gate, the administrative and office blocks, residential buildings and a 4 km stretch of electric fence are all submerged in water (Plate 15). In a number of public campsites, also, ablution facilities and roads have been affected. It is estimated that KWS will require KSh 25 million to replace the submerged gate and KSh 12 million to rehabilitate the electric fence. KWS has incurred expenses in demolishing structures that were being submerged as well in relocating the offices and staff to temporary facilities, bringing the total cost to approximately KSh 50 million.

Plate 15: Submerged main entrance to Lake Nakuru National Park. A large part of the park has been marooned.

Many who have been displaced from their homesteads have raised legal land issues and the government has been requested to intervene by resettling the affected persons. Human-wildlife conflict cases have also been reported especially where hippos stray into farmlands around the Lake. KWS officials however managed to repulse these animals, and there have been no reported cases of injuries or fatalities.

2.1.8 Lake Elmenteita

The rising water levels have adversely affected livelihoods of communities around the lake. There has been loss of pasture and grazing and lands. The submersion of hot springs as shown in Figure 22, and the migration of flamingos and other birds have affected tourism. The reduction in numbers of tourists has contributed to loss of revenue to the national and county governments as well as to the local community that largely depended on tourism for employment.

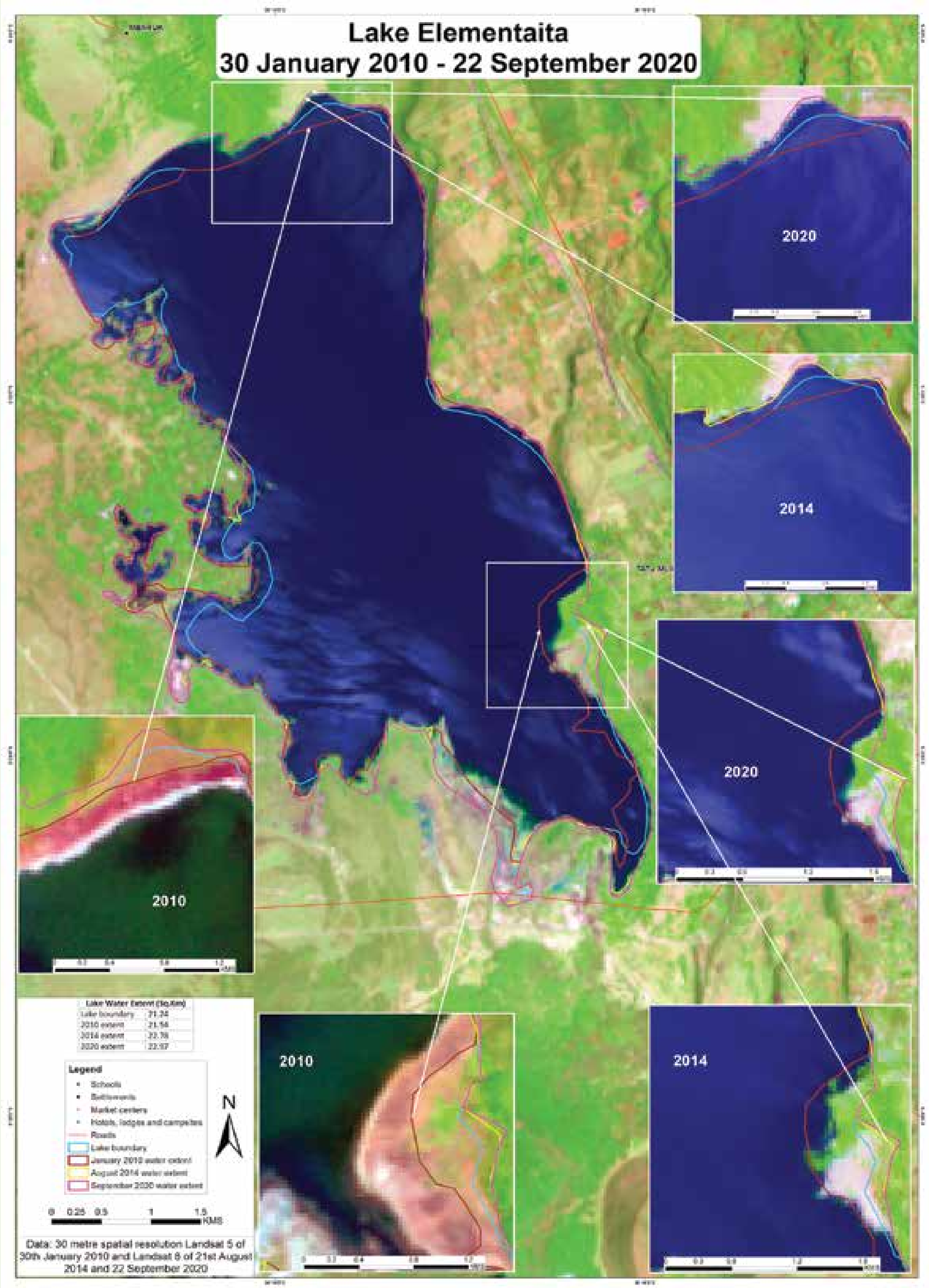


Figure 22: Lake Elmenteita Floods extent

Rising water levels in Lake Elmenteita resulted in flooding though this did not result in displacement of settlements around the lake. The water levels in 2020 did not rise beyond what was recorded in 2014 (Figure 23).

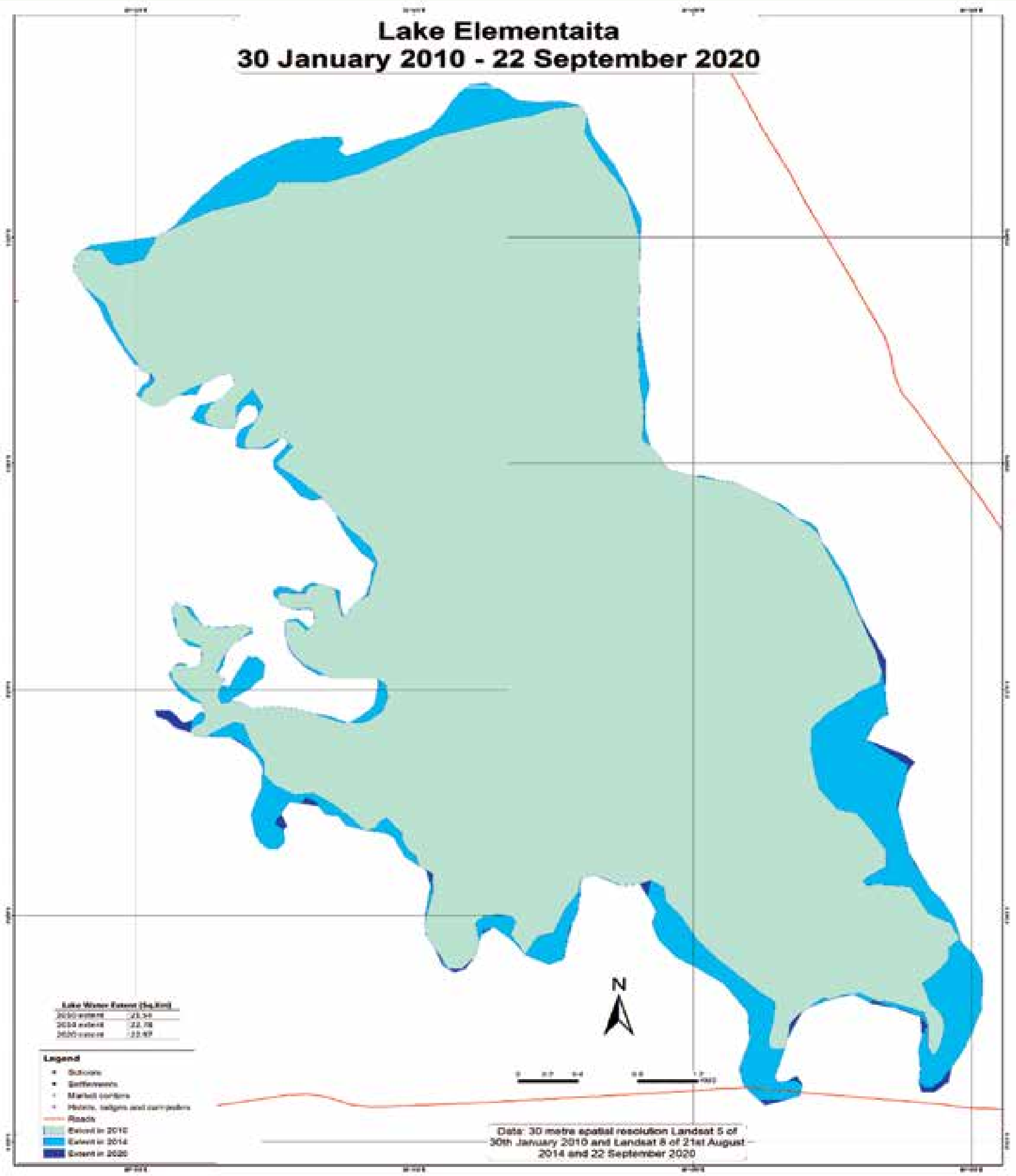


Figure 23: Map of Lake Elmenteita floods Extent

Hotels and other facilities located in the eastern shoreline may potentially experience floods if the waters continue to rise. About 5 acres belonging to Sentrim lodge could be submerged too. Other hotels and camps on the eastern shoreline which may potentially be affected include Epashikino Resort and Spa, Eagles Point Camp, Cactus Eco Camp, Jacaranda, and Serena Camp. Issues of land rate payments and license renewals may come up.

2.1.9 Lake Naivasha

At Lake Naivasha, the areas affected include the Kihoto Settlement and Kamere beach (plate 16) and a number of hotel facilities (plate 17) where over 1500 households have been displaced, substantial number of constructed properties and several power transformers have been submerged, posing a hazard to the community. 6 people died in Kihoto because of distress and depression after their properties were destroyed. The fisher-folk have lost livelihood due to beaches getting submerged. There is conflict between the licensed and unlicensed fishermen and joint patrols to reduce this are being coordinated by the Department of Fisheries.

There have also been reports of human-wildlife conflict where hippos who now graze closer to human settlements are attacking humans. It was further established that the Kihoto and Karagita areas are the most populated and the rising waters have heightened security issues. Although fish traders on Kamere public beach have experienced increased fish yields, they have experienced losses as many fish get spoiled before reaching the market. The only available methods for preserving the fish are sun drying and deep frying. Furthermore, the rising water levels have reduced business for the prime tourist hotel thus cutting down on employment. According to the State Department of Agriculture, by August 2020, 264.8 ha of land and 170 households in Nakuru County had been affected by the rising water levels. A significant proportion of the acreage affected is around Lake Naivasha (Figure 24). Following the loss of land and properties in Kihoto, specifically, legal issues are bound to arise as the owners seek to be relocated or compensated by the relevant institutions. Through the Homeowners Association leadership, the residents have aired their grievances but which they claim have not been addressed.

Plate 16: Flood water impacts at Kihoto Village and Kamere Beach along shores of Lake Naivasha

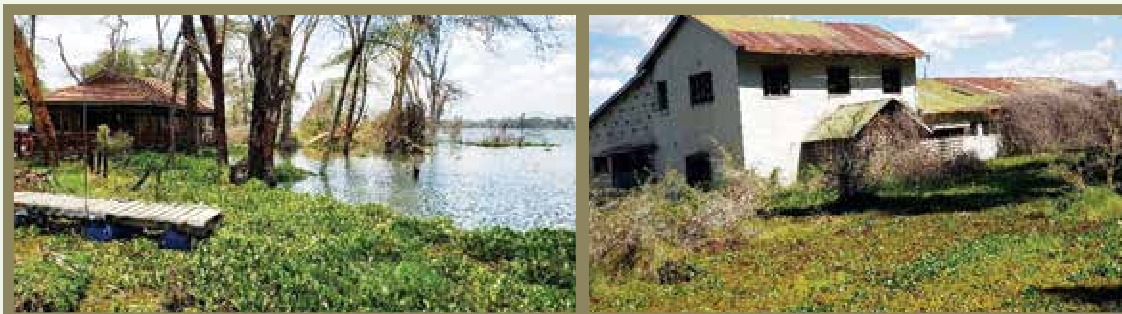
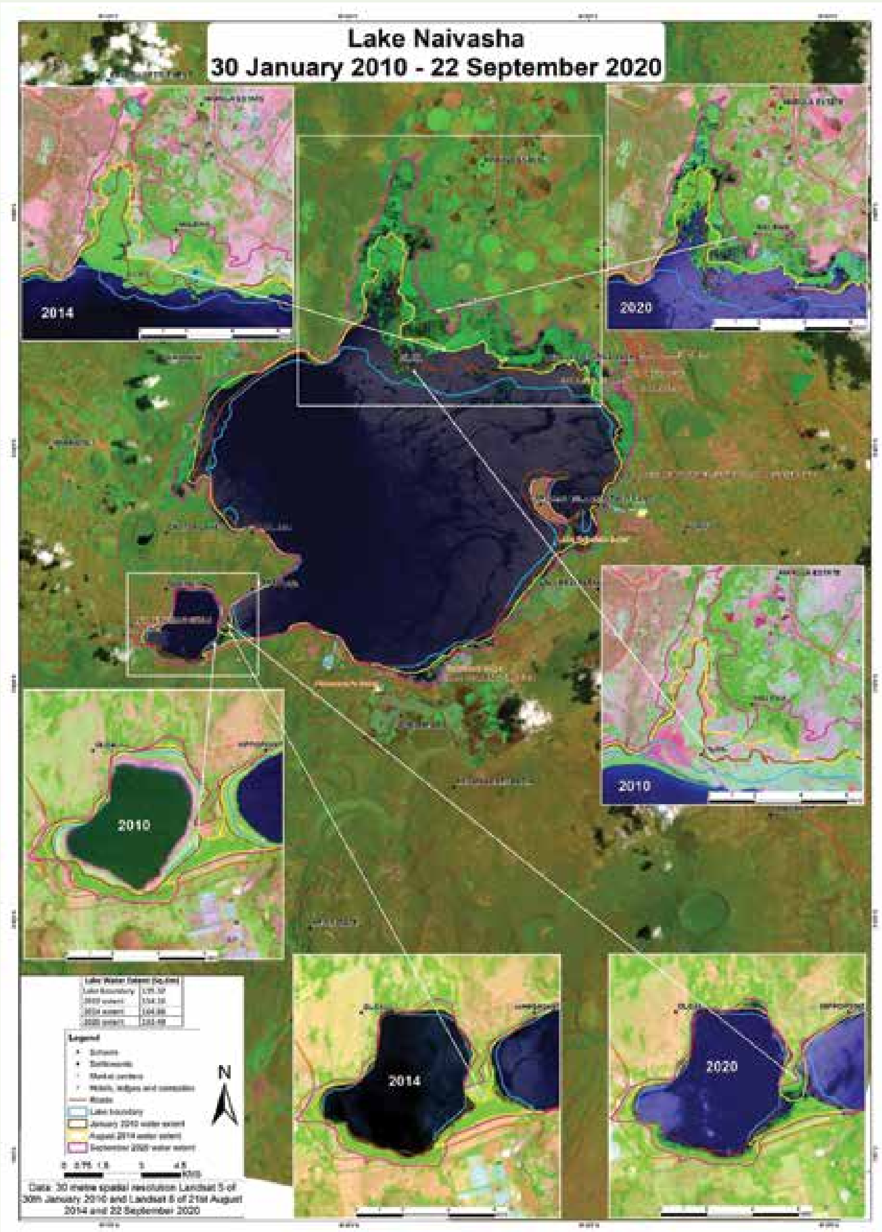


Plate 17: Submerged hotels business premises at Lake Naivasha



A significant proportion of the acreage affected **is around Lake Naivasha.**

Figure 24: Image of Lake Naivasha showing the floods extent.

Lake Naivasha is among the lakes that were majorly affected by the rising water levels. Large areas of land were submerged causing displacement of many who lived around the lake (Figure 25). Many small enterprises that relied the lake were also displaced.

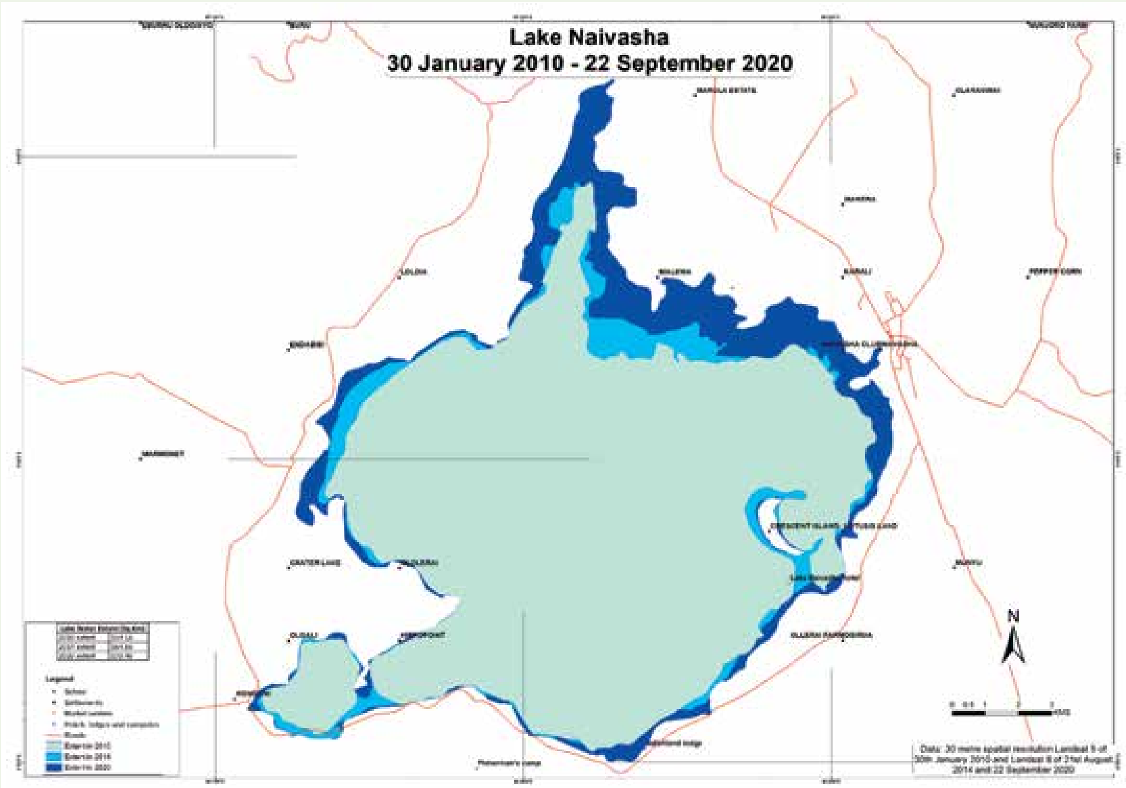


Figure 25: Map showing areas affected by the flood waters of the rising Lake Naivasha.

2.1.10 Lake Magadi

An area of about 20 km^2 estimated to cover 30% of Lake Magadi is currently covered by silt. This siltation has hindered trona mining and subsequently affected the livelihoods of an estimated 50,000 community members and 600 employees that work for Tata Chemicals Magadi Ltd (TCML). Farming activities in the upper and middle catchment areas of River Kisamis, a seasonal river that drains into Lake Magadi, have been affected following increased runoffs and environmental degradation upstream of both river Kisamis and Ewaso Nyiro South. This has deeply affected the livelihoods of communities living in the area. Moreover, the excavation of trenches around Kedong Ranch has created deep gullies, increasing flows of silt into river Kisamis. Further, large scale sand harvesting around Suswa area in Nakuru and Narok Counties has loosened soils and increased erosion. In addition, the construction of the Maai Mahiu-Narok Road and the Standard Gauge Railway (SGR) has contributed to the creation of deep gullies through guided convergence of streams. The lake water rise in Lake Magadi did not have much impact as the submerged land areas were minimal leading to minimal or no settlement displacement (Figure 26 and Figure 27).

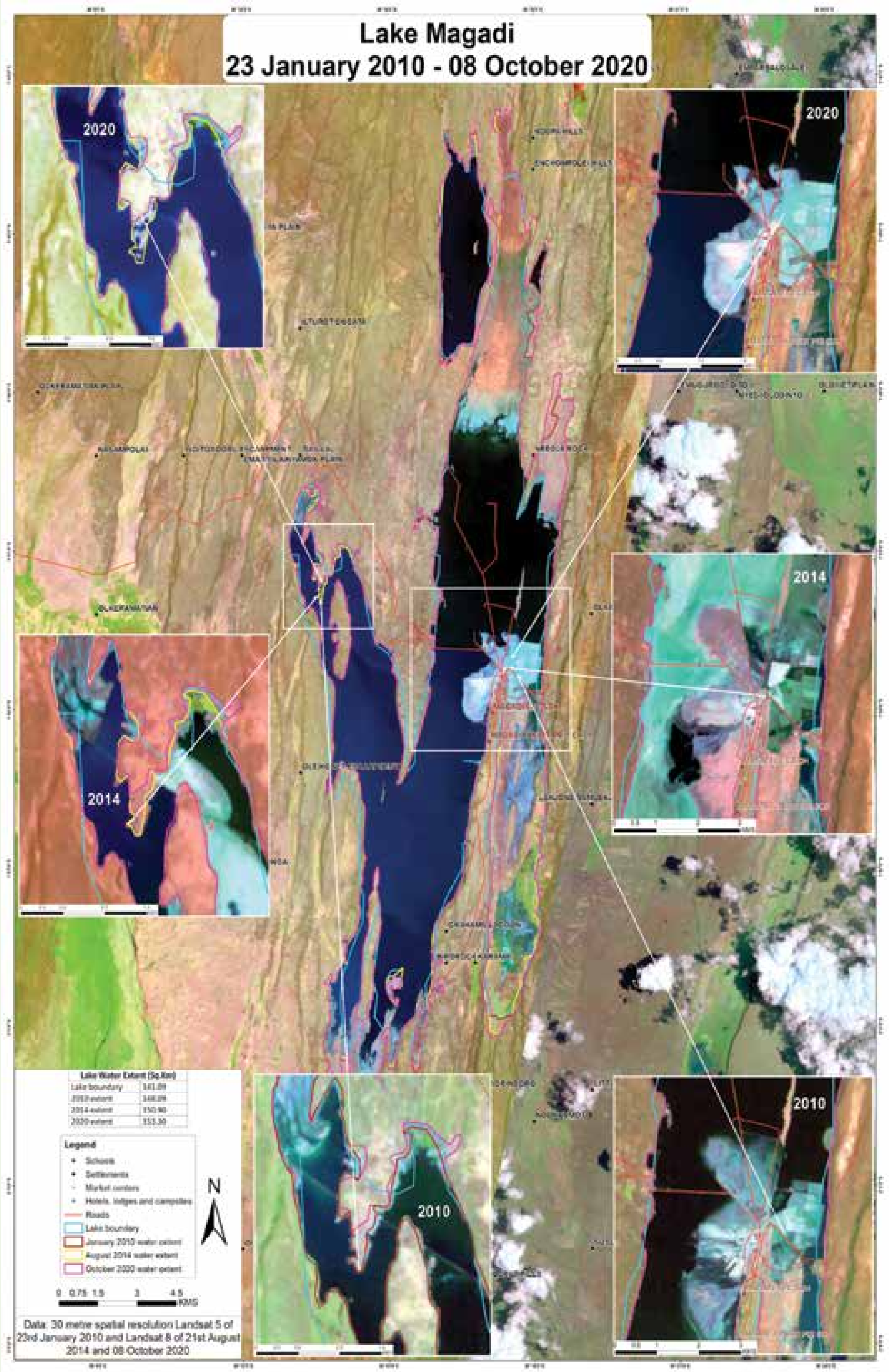


Figure 26: September 2020 Landsat image showing absence of soda ash in Lake Magadi which otherwise is normally completely covered in a cake of trona.

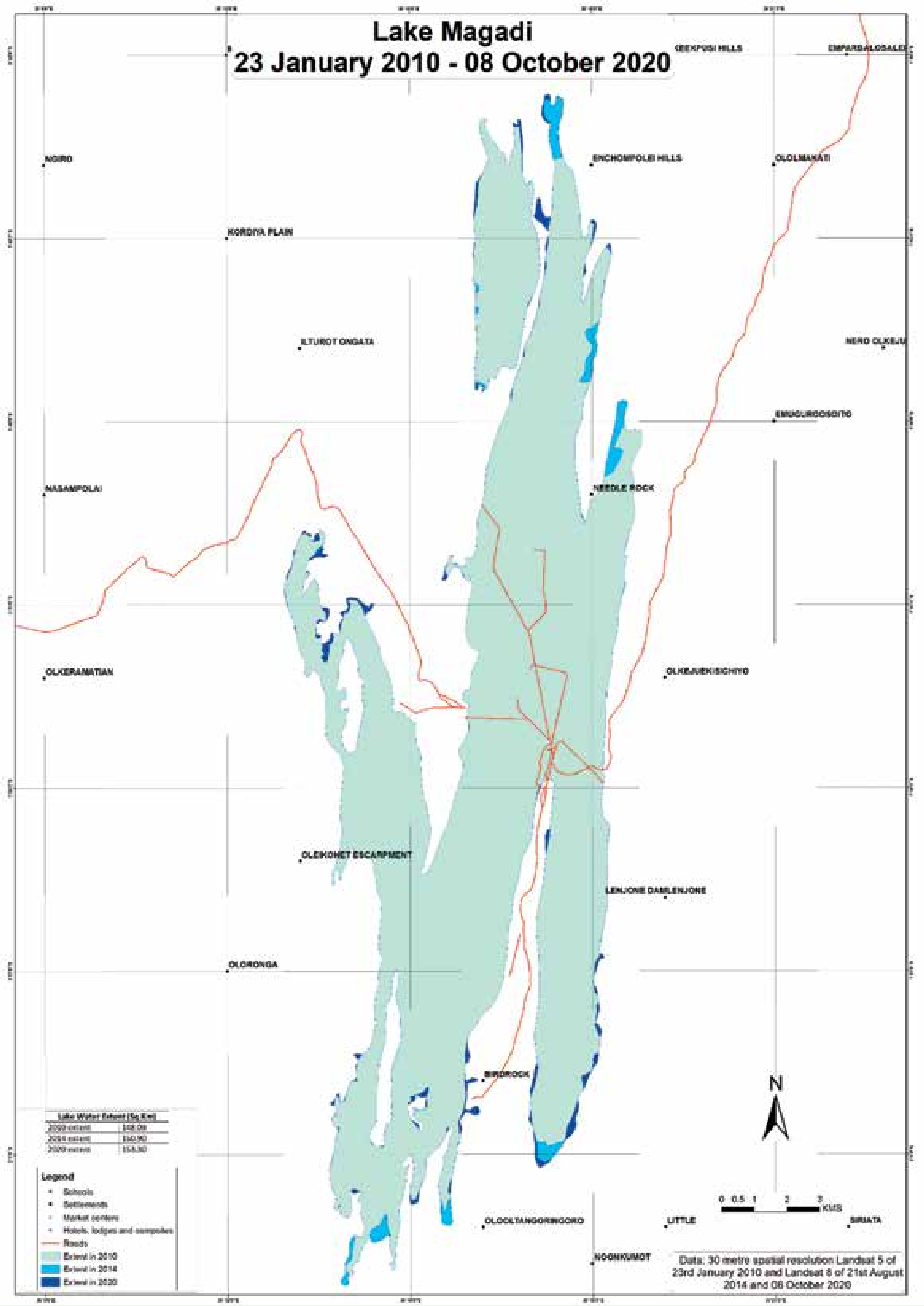
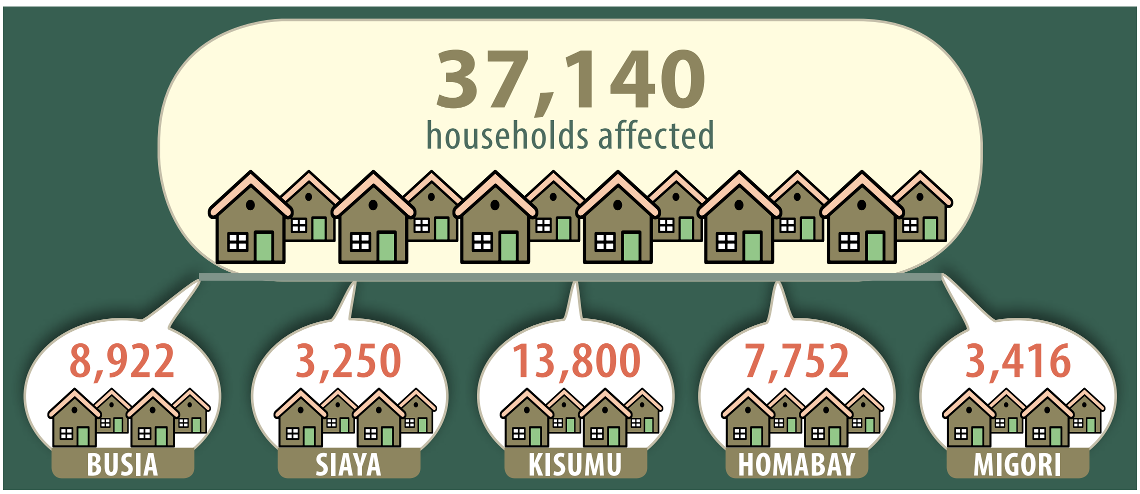


Figure 27: Lake Magadi areas affected by the flood waters, most of the soda ash dissolved due to excess water input.

People have been displaced in some places where water levels have risen high enough to submerge their homes and their lands. This has happened in the Kikuyan area in Narok where Kikuyani Primary School, a church and several homes have been submerged in water, displacing children and local residents. This has resulted in serious health problems including an increase in water borne diseases such as cholera because the pit latrines in Kikuyan Primary School overflowed, contaminating water that local residents use for domestic consumption. Other emerging concerns include the lack of data on the highest and lowest water levels ever recorded for various water bodies, a matter that decisively affects land compensation strategies. Reports were also made of loss of human and animal lives due to the flash floods. The floods also exposed fault lines and created sinkholes in Nairage Enkare. The subsequent construction of silt diversion dykes has caused tension within the Purko pastoral community.

2.1.11 Lake Victoria

All five counties bordering Lake Victoria have continued to experience a unique type of flooding that is linked to the rising water levels in Lake Victoria. At least 37,140 households have been affected—8,922 in Busia, 3,250 in Siaya, 13,800 in Kisumu, 7,752 in Homabay and 3,416 in Migori. Kisumu and Busia counties remain the most affected with at least 22,722 families displaced, including 6,245 in Bunyala sub county (Bunyala South, Bunyala Central and Bunyala West – in Busia County, and 1,200 in Ogenya and Ombaka Kanyangwal in Nyando, Kisumu County. These families are in dire need of humanitarian assistance. Their houses and farming fields are still submerged in flood waters. Their economic activities have been crippled as they mostly relied on farming and fishing. Their social amenities were not spared either—learning institutions (primary and secondary schools), health facilities, markets, sanitation facilities, water supply units like boreholes and shallow wells, and even road networks have significantly been destroyed. Some have turned to boat transport to access services across the flooded areas. Figure 28 shows the extent to which lands in these counties have been submerged.



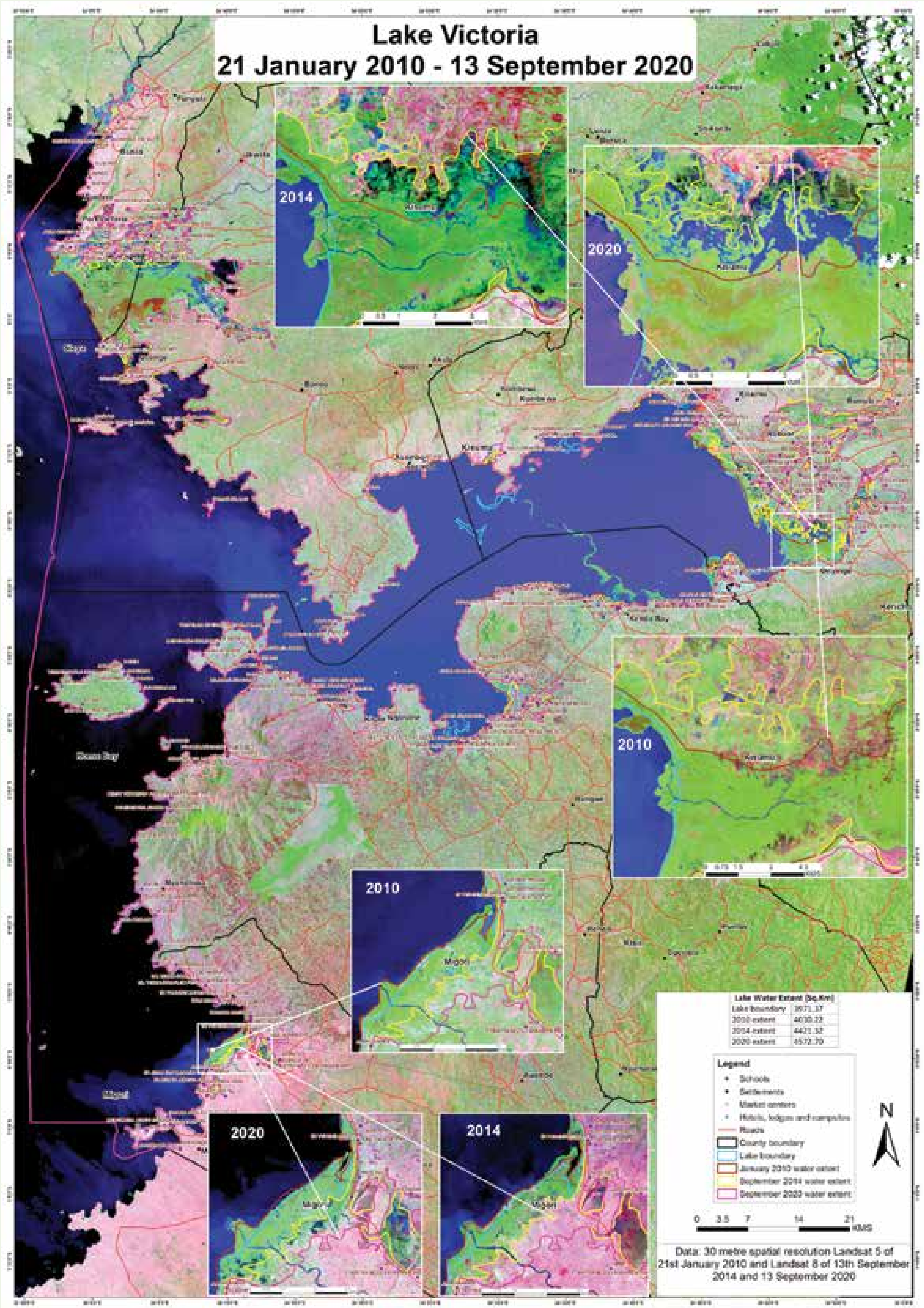


Figure 28: The Lake Victoria flood extent from the lake level rise. Higher flood impacts and submergence are seen in bays, gulfs and inlets.

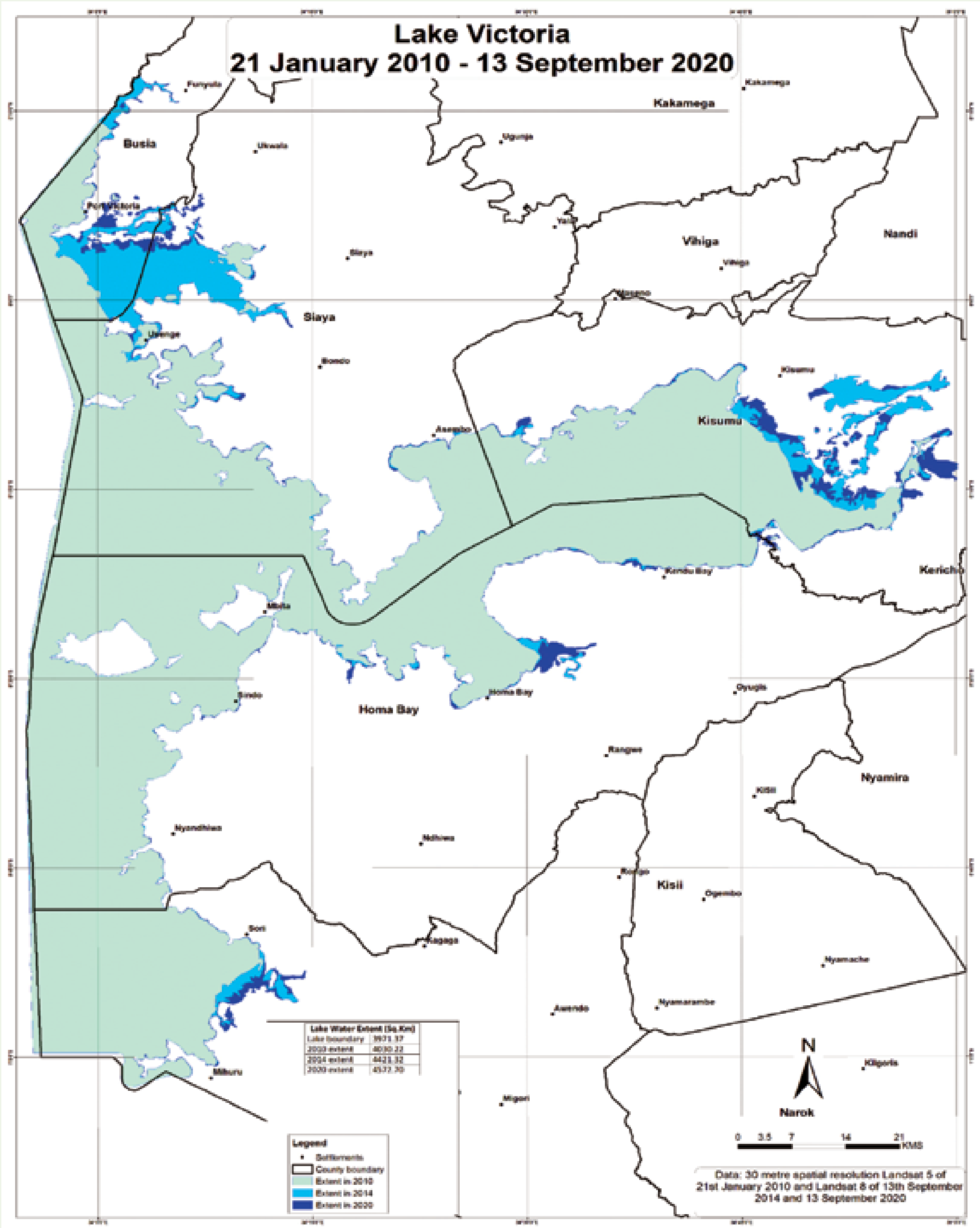


Figure 29: Map of Lake Victoria area showing significant flooded areas along the lake.

The affected families largely rely on support in form of food rations and other necessities from the national and county governments, Kenya Red Cross Society (KRCS) and well-wishers. The extent of disruptions to their socio-economic lives means that they are supposed to re-establish and adopt new ways of survival, meaning they might have to continue living in the camps or with those hosting them for much longer, keep changing schools for their children, and spend more time finding and fitting into new markets as they re-establish their forms of livelihoods.

The flooding situation caused by the backflow of waters from Lake Victoria is worrying since there is no clear-cut timeline when the water levels will reduce and once again allow the affected communities to re-settle back to their family land. As it is, the situation becomes worse with March April May (MAM) and October November December (OND) rains.

More than 100 fish landing beaches and bandas at Muhuru Bay, Sori, Usenge and Bunyala South were submerged (Plate 19). Small and medium enterprises like boat making, flour milling, small eateries, shops and salons, as well as several establishments that served both the fishermen and visitors were affected at the time of our visit. The county has a number of hotels along its beaches and some of them like Impala Eco Lodge have been submerged (Plate 18). The sanctuary park shrunk by 4.7 km^2 and the Kisumu Golf Club is out of use.


Plate 18: A section of Got Kochola Beach and the Impala Eco Lodge are submerged.

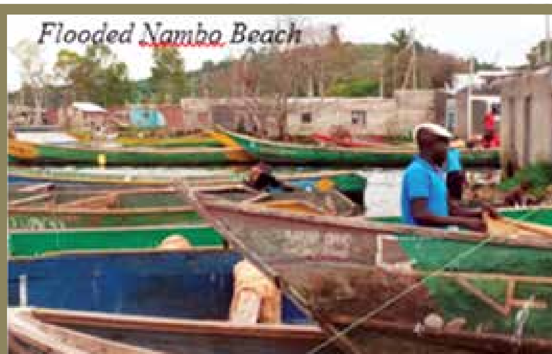


Plate 19: Flooded Bondo water supply and Nambo Beach in Siaya County.

It was reported that floods have historically been recurring but not to the magnitude witnessed this time. A situation similar to the present one was last experienced in the early 1960's. Majority of the residents in these counties feel that the lake is reclaiming its original land. Legal owners of lands around the lake are likely to seek compensation for what they lose. Concerning security and human-wildlife conflict, people increasingly feel unsafe as hippos now graze closer to human settlements. Several deaths caused by attacks by hippos have been reported.

2.2 Ecology and Biodiversity of the Lakes

2.2.1 Lake Turkana and its Catchment

Lake Turkana is an extremely important waterbird site: 84 waterbird species, including 34 Palearctic migrants, have been recorded here. These include *Calidris minuta*. The lake is a key stop-over site for birds on passage. Waterbirds are distributed all around the lake, but the highest densities are on mud and pebble shores. At least 23 species of birds breed here, including *Ardea goliath, Rynchops flavirostris, Casmerodius albus, Ephippiorhynchus senegalensis* and *Circaetus cinerascens*.

Lake Turkana also supports a rich diversity of freshwater fish. About 60 species of fish belonging to 20 families are known to exist in the Lake Turkana region. Forty-eight of the species are in the lake and twelve species are endemic, including *Barbus turkanae, Neobola stellae, Brycinus ferox, Brycinus minutus, Chrysichthys turkana, Aplocheilichthys jeanneli, Aplocheilichthys rudolfianus, Haplochromis macconneli, Haplochromis rudolfianus, Haplochromis turkanae, Hemichromis exsul and Lates longispinis*. The Omo delta hosts more than 15 different fish families. These include some unique species of fish such as mormyrids (freshwater elephant fish): *Mormyrus longirostris, Marcusenius victoriae, Marcusenius macrolepidotus, Mormyrus anguilloides, Mormyrus kannume, Marcusenius stanleyanus, Hyperopisus bebe,* the African arowana and the African knife fish (an electric fish) and *Polypterus senegalus*. The common species for commercial fishing include *Clarias gariepinus, Oreochromis niloticus, Labeo horie, Barbus bynii, Citharinus citharus, Distichodus nefasch, Bagrus docma, Lates longispinis, Schilbe uranoscopus, Alestes baremoze* and *Bagrus bayad"*. The sheltered muddy bays with beds of waterweed Potamogeton are important for fish spawning. The fish in turn support a large population (estimated at some 14,000 in 1968) of Nile Crocodile, *Crocodylus niloticus*.

Assessment of land cover carried out between 2000 and 2018 shows that there was a slight decrease in forest cover from 3.5% in 2000 to 3.1% in 2018. Cropland on the other hand recorded a steady increase from 0.2% in 2000 to 0.9 % in 2018. Wetland also increased between the two periods from 6.88% to 6.95% (Table 3 and Figure 30). This signifies that there was conversion of forest to cropland and that the lakes within the catchment expanded hence decreasing the size of grassland as illustrated by an extract from Google Earth images showing the Uri Border point at Ileret (Figure 31).

Table 3: Land cover for Lake Turkana catchment area.

Basin Land Cover	Area (km^2)	Cover	Area (km^2)	Cover	Area (km^2)	Cover	Area (km^2)	Cover
Turkana Basin	**2000**	**% total**	**2010**	**% total**	**2014**	**% total**	**2018**	**% total**
Forest	3762.6	3–5	5149.3	4.8	4703.1	4.4	3272.9	3.1
Wooded Grassland	44469.7	41.6	43978.4	41.1	45798.1	42.8	45361.8	42.4
Open Grassland	17331.6	16.2	15879.9	14.9	13677.7	12.8	15052.1	14.1
Cropland	256.5	0.2	681.1	0.6	746.3	0.7	978.3	0.9
Vegetated Wetland	12.1	0.0	79.0	0.1	88.9	0.1	134.3	0.1
Open Water	7346.3	6.9	7339.1	6.9	7329.0	6.9	7297.2	6.8
Total wetlands	7358.43	6.88	7418.07	6.94	7417.82	6.94	7431.45	6.95
Other Land	33731.3	31.6	33803.3	31.6	34567.1	32.3	34813.5	32.6
Total	**106910.1**	**100.0**	**106910.1**	**100.0**	**106910.1**	**100.0**	**106910.1**	**100.0**

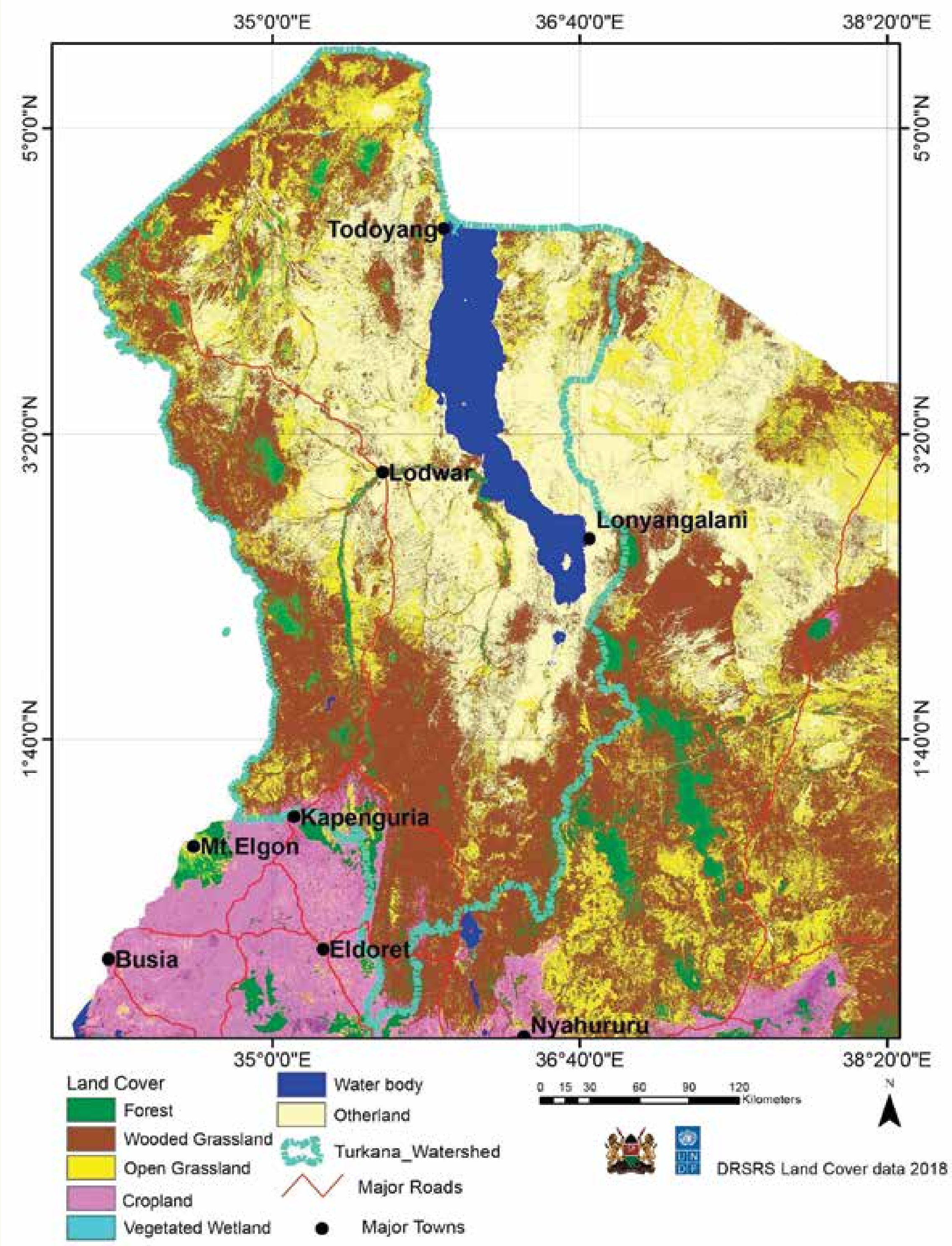


Figure 30: Land cover map for lake Turkana showing the area mainly under wooded grassland and other lands that are mainly bare soils.

Figure 31: Takeover of open grassland by flood waters of Lake Turkana as illustrated in the Google Earth image extract of 2005 and 2012 of Uri border point at Ileret.

2.2.2 Lake Baringo

Lake Baringo is rich in biodiversity. It is home to seven freshwater fish with *Oreochromis niloticus baringoensis* being endemic. Other fish species found in the lake include *Barbus spp., Labeo spp.,* catfish and lungfish. The lake is also a refuge for nearly 500 species of bird with more than 20,000 individual birds recorded. Some globally threatened bird species like *Falco naumanni, Phoenicopterus minor, Ardeola idea and Circus macrourus* are known tovisit the lake. A number of regionally threatened species are also recorded there, like *Podiceps cristatus, Anhinga rufa, Casmerodius albus, Ephippiorhynchus senegalensis, Thalassornis leuconotus, Trigonoceps occipitalis, Polemaetus bellicosus, Porzana pusilla* and *Rynchops flavirostris*. Many other animals including hippos, *Hippopotamus amphibious;* crocodiles, *Crocodylus nilotica;* and a wide range of mammals, amphibians and reptiles including a range-restricted snake, *Coluber keniensis,* inhabit the lake. There was a sizable population of Rothschild's giraffe, *Giraffa camelopardalis rothschildi,* in Ruko Conservancy on Rokos island. Currently, however, the population of these giraffes has decreased after some of them were relocated following the flooding of the island (Figure 32).

Figure 32: The flood impacts on Rukos Conservancy in Lake Baringo where the island was completely disconnected from the mainland leading to the need to translocate wildlife marooned in the island

Land cover assessment done between 2000 and 2018 shows that there was an increase in forest cover between 2000 and 2014, followed by a decrease between 2014 and 2018. Wooded grasslands on the other hand decreased throughout the mapping period, from 52.5% in 2000 to 50% in 2018. Conversely, cropland increased from 24.8% to 32.6% between 2000 and 2018 while Wetland in the catchment increased from 1.96% in 2000 to 2.95% in 2018 (Table 4 and Figure 34). Fluctuation in forest and wooded grassland may be attributed to behaviour of Prosopis vegetation whenever there is change in the weather pattern. An increase in cropland indicates that more vegetation is converted to farmland and the increase in wetland signifies the increase in water levels of the lakes within the catchment.

Table 4: Land cover for Lake Baringo catchment area.

Basin Land Cover	Area (km²)	Cover	Area (km²)	Cover	Area (km²)	Cover	Area (km²)	Cover
Baringo	2000	% total	2010	% total	2014	% total	2018	% total
Forest	563.7	8.5	592.3	8.9	769.6	11.5	513.9	7.7
Wooded Grassland	3501.8	52.5	3365.6	50.5	3322.3	49.8	3333.4	50.0
Open Grassland	737.9	11.1	737.2	11.1	600.4	9.0	392.2	5.9
Cropland	1652.6	24.8	1748.0	26.2	1691.5	25.4	2175.3	32.6
Vegetated Wetland	1.3	0.0	0.0	0.0	21.1	0.3	14.6	0.2
Open Water	129.5	1.9	142.0	2.1	199.8	3.0	182.2	2.7
Total wetlands	130.78	1.96	141.98	2.13	220.91	3.31	196.83	2.95
Other land	78.0	1.2	79.5	1.2	60.0	0.9	52.9	0.8
Total	**6664.8**	**100.0**	**6664.6**	**100.0**	**6664.7**	**100.0**	**6664.5**	**100.0**

The extent of the damages these floods have wrought on the riparian land around Lake Baringo Lodge are shown on a snapshot of Google Earth snapshot images (Figure 33).

Figure 33: Evidence of the extent of flooding from the rising lake Baringo level and the damage it has brought to the development infrastructure (from Google Earth images of Feb 2001 and August 2019)

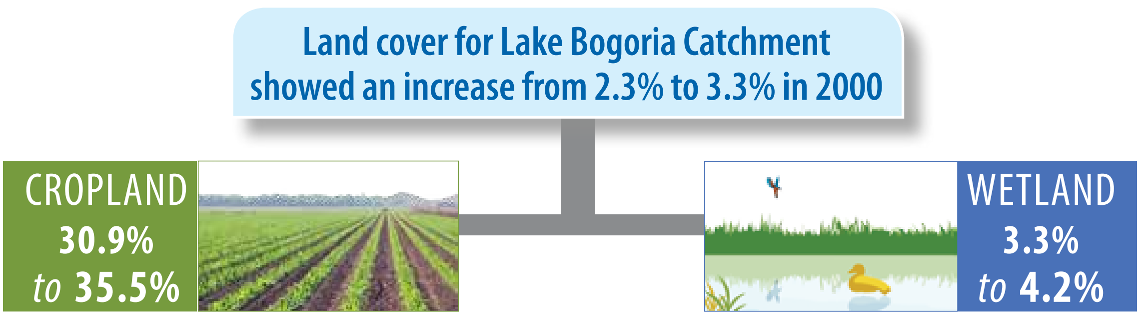
2.2.3 Lake Bogoria

The terrestrial vegetation around Lake Bogoria is mainly thorny bushland, dominated by species of *Acacia, Balanites and Commiphora,* with patches of riverine woodland containing *Ficus capensis, Acacia xanthophloea and A. tortilis.* The open shore, often littered with lava boulders, is dominated by alkaline-tolerant grasslands of *Sporobolus spicatus*, with the sedge *Cyperus laevigatus* around the hot springs. The lower slopes of the Siracho escarpment are covered by *Combretum* and Grewia thicket. Lake Bogoria is a key feeding ground for the itinerant Rift Valley population of the Near Threatened Lesser flamingo *Phoenicopterus minor. Podiceps nigricollis* and *Anas capensis* are usually present in good numbers. Other species of concern to global conservationist efforts recorded at Bogoria include *Circus macrourus* and *Falco naumanni.* Regionally threatened species include *Podiceps cristatus; Anhinga rufa* (has occurred in swamp to north of lake); *Oxyura maccoa; Thalassornis leuconotus; Trigonoceps occipitalis;* and *Polemaetus bellicosus.* The lake usually supports a dense bloom of the *cyanophyte Spirulina*. The hot springs contain a highly specialized microbial fauna, with several endemic species.

Land cover for Lake Bogoria Catchment showed an increasing trend in forest, wetland and cropland between the years 2000 and 2018. The forest cover increased from 2.3% in 2000 to 3.3% in 2018 (Table 5 and Figure 33). Wetland and cropland on the other hand increased from 3.3% and 30.9% to 4.2% and 35.5% respectively. The increase in wetland is an indication that the water levels of Lake Bogoria have steadily increased during this period.

Table 5: Land Cover for Lake Bogoria catchment area.

Basin Land Cover	Area (km^2)	Cover	Area (km^2)	Cover	Area (km^2)	Cover	Area (km^2)	Cover
Bogoria-Solai	**2000**	**% total**	**2010**	**% total**	**2014**	**% total**	**2018**	**% total**
Forest	26.5	2.3	26.5	2.3	61.7	5.3	38.7	3.3
Wooded Grassland	618.4	52.8	618.4	52.8	558.1	47.6	573.5	48.9
Open Grassland	121.8	10.4	121.8	10.4	104.0	8.9	89.1	7.6
Cropland	361.9	30.9	361.9	30.9	387.6	33.1	416.5	35.5
Vegetated Wetland	0.2	0.0	0.2	0.0	3.5	0.3	2.5	0.2
Open Water	38.9	3.3	38.9	3.3	52.3	4.5	46.9	4.0
Total wetlands	39.08	3.33	39.08	3.33	55.77	4.76	49.38	4.21
Other land	4.5	0.4	4.5	0.4	5.2	0.4	5.1	0.4
Total	**1172.2**	**100.0**	**1172.2**	**100.0**	**1172.2**	**100.0**	**1172.2**	**100.0**



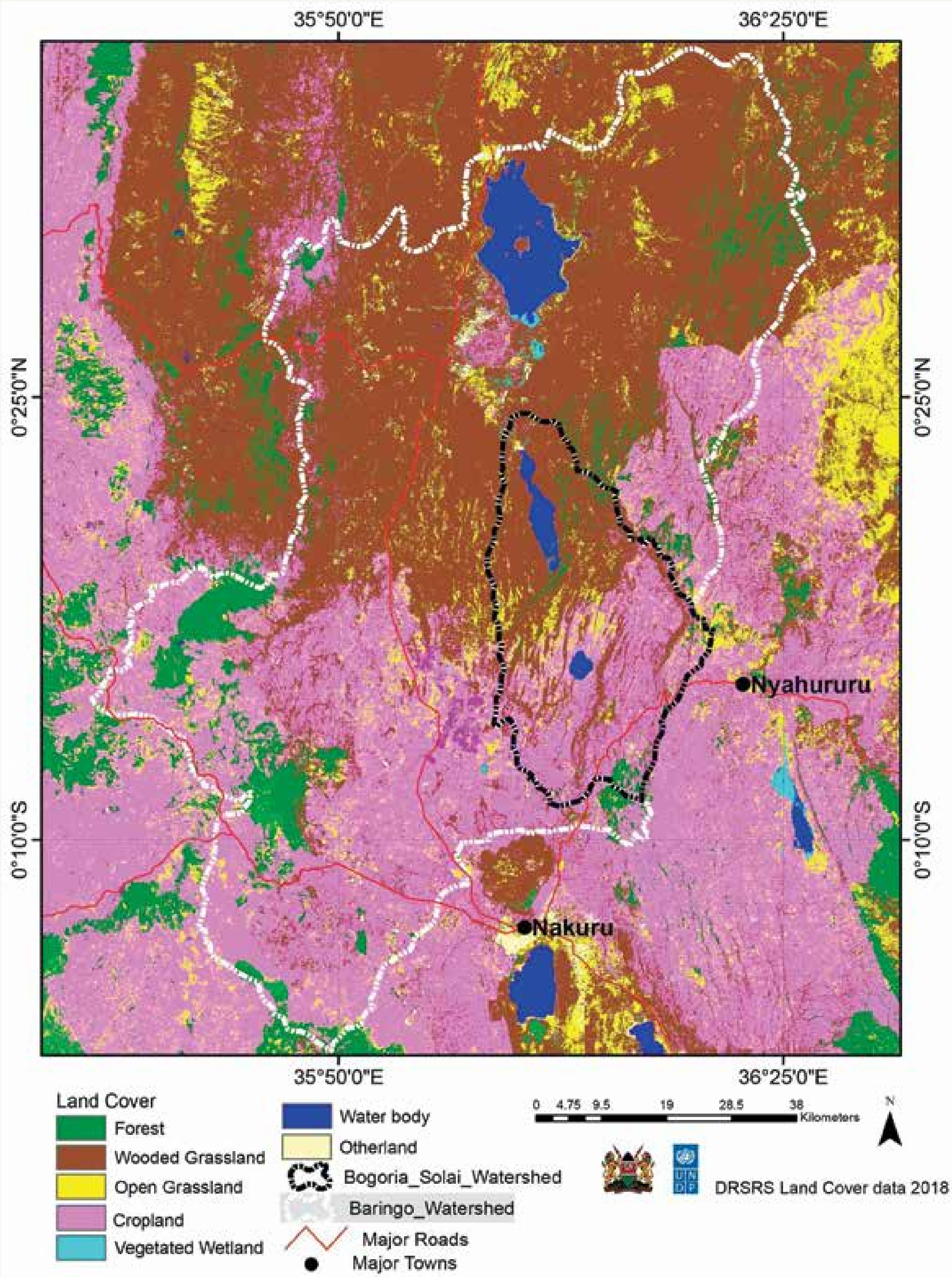


Figure 34: Land cover map for the northern parts of the Kenya dome containing lakes Bogoria and Baringo. Note that Lake Solai is within the watershed of Lake Bogoria

2.2.4 Lake Solai

The area is rich in flora and fauna. Diverse vegetation and dominant tree species including *Acacia xanthopholea, Acacia seyal, Sesbania spp and Banalities aegyptiaca* are found around this lake. Water birds are conspicuous, with over 100 species of water birds having been recorded on the lake. Squacco Heron breads on the shores of this lake. The most abundant groups are Afro tropical ducks and geese, Rails, gallinules and coots, ibises and spoonbills, abundant species being Red-Knobbed Coot, Egyptian Goose, Sacred Ibis and Yellow-billed Duck. In addition, 30 Paleartic and 15 afrotropical migrant species have been recorded at the lake. The nearly threatened Lesser Flamingo is found in this lake whenever environmental conditions in other lakes in the Rift Valley are hostile to flamingos. Bird species found in this lake include Grebes, Pelicans, Herons, Storks, Ibis, Ducks, Geese, Pintail, Teals, African Jacana, Plovers, Sandpiper, Stints, Avocet, Tern, Moorhen, Red Knobbed Coot, African Marsh Harrier, Crested Crane, Gull, etc. Game birds include Pigeons, Doves, Chikoons, Coucals, Volleys, Bee-eaters, Honey Guides, Owl, Night Jar, Woodpecker, Swift, and Weaver. Wildlife species found in this area include Zebra, African Hare, Mongoose, Squirrel, Dik-Dik and Hyena. Reptiles include Python, Puffadder, Monitor Lizard and other lizards and Tortoise. Insects include Water Striders, Water Boatman, Backswimmer and leeches. Fish species in the lake include tilapia and catfish. The fish is thought to have escaped from fish farms in the surrounding areas during flooding seasons. Figure 35 shows the increase in the size of the lake.

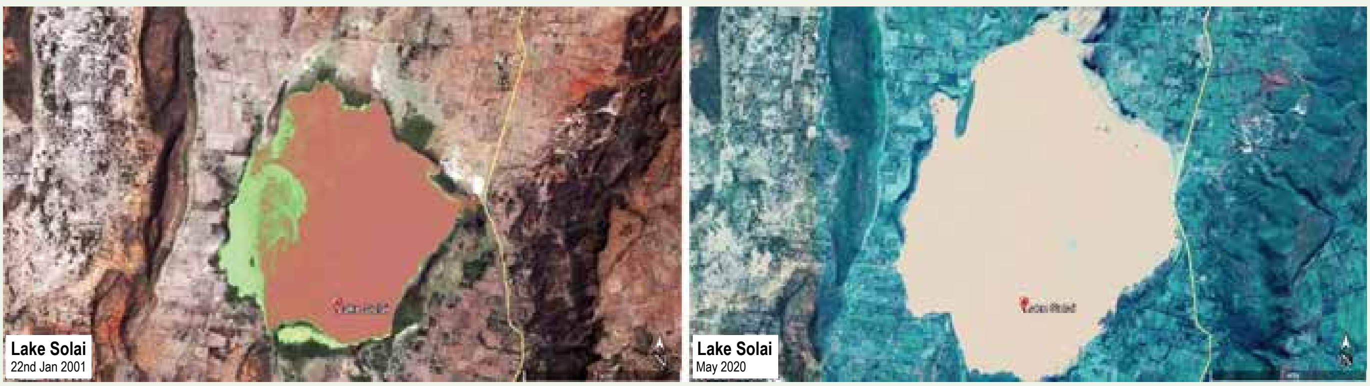


Figure 35: Extensive changes in Lake Solai level rise as seen in the Google Earth image extracts of January 2001 and May 2020

2.2.5 Lake Ol' Bolossat

The Lake Ol' Bolossat is known to be important for Palearctic migrant waterbirds. During a survey in 2007, 17 species of waterbirds that are listed by the African-Eurasian Waterbird Agreement were recorded. The area around Lake Ol' Bolossat holds a significant area (39 sq. km.) of unique montane grasslands. The highland grasslands of central Kenya contain a suite of restricted-range bird species, forming part of Kenyan Mountains Endemic Bird Area.

Sharpe's Longclaw *Macronyx sharpei,* a globally threatened and Kenyan high-altitude grassland endemic bird, was recorded in the area's open grasslands during a waterfowl census in early 2007. Suitable habitat for Sharpe's Longclaw in Kenya is found in Kinangop, Mau Narok & Molo grasslands, and Uasin Gishu plateau. Long-tailed Widowbird E. progne, a regionally threatened species, was also observed. Hunter's Cisticola *Cisticola hunteri* (Least Concern) was recorded mainly in bushes in the farmlands. The Lake's open water and swamps are home to a number of waterbirds. Interesting species observed include African Marsh Harrier, Purple Swamphen, Black-bellied Bustard and Capped Wheatear. Other abundant species include Long-tailed Widowbird, Red-capped Lark and Grassland Pipit. There are many Hippopotamuses, estimated at over 200 individuals, which graze overnight and are a source of human-wildlife conflicts.

Land cover within the catchment of Lake Ol' Bolossat showed an upward trend in Wetland and Cropland between the year 2000 and 2018. Forest cover on the other hand decreased from 2.7% in 2000 to 1.9% in 2018 (Table 6 and Figure 36). This may be due to harvesting of Eucalyptus which is common in the private farms in the catchment. The increase in wetland is an indication of the rising levels of water in the lake.

Table 6: Land cover for Lake Ol' Bolossat catchment area.

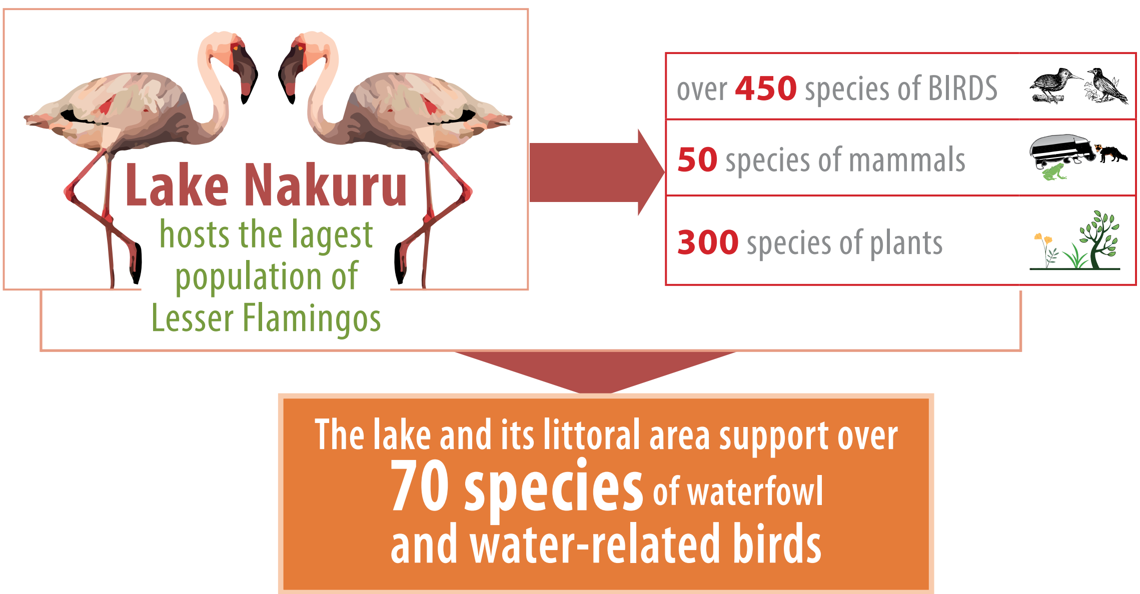
Basin Land Cover	Area (km^2)	Cover	Area (km^2)	Cover	Area (km^2)	Cover	Area (km^2)	Cover
Ol' Bolossat	2000	% total	2010	% total	2014	% total	2018	% total
Forest	15.4	2.7	29.9	5.2	31.4	5.5	10.6	1.9
Wooded Grassland	84.5	14.8	80.7	14.1	104.7	18.3	42.3	7.4
Open Grassland	141.5	24.8	102.6	18.0	87.9	15.4	61.8	10.8
Cropland	320.8	56.2	347.2	60.8	310.8	54.4	424.4	74.3
Vegetated Wetland	8.0	1.4	8.4	1.5	8.1	1.4	15.1	2.6
Open Water	0.9	0.2	2.3	0.4	25.5	4.5	14.9	2.6
Total wetlands	8.96	1.57	10.72	1.88	33.65	5.89	29.99	5.25
Other land	0.0	0.0	0.0	0.0	2.7	0.5	2.1	0.4
Total	**571.2**	**100.0**	**571.2**	**100.0**	**571.2**	**100.0**	**571.2**	**100.0**

2.2.6 Lake Nakuru

Lake Nakuru is globally renowned for hosting the largest population of Lesser Flamingos—what has been described as *"the world's greatest ornithological spectacle".* With over 450 species of birds, 50 species of mammals and 300 species of plants, it is one of the highest biodiversity parks in the country. The lake and its littoral area support over 70 species of waterfowl and water-related birds. Each year the resident bird life of the park is enriched by the presence of several species of Palearctic waders that use the lake as a staging ground during their winter migration down the Rift Valley fly way. The lake has faced major ecological restructuring as a result of flooding. Previously, the foundation of the lake's simple food chains was the cyanophyte *Spirulina platensis,* which often occurred as a unialgal bloom. At such times it could support huge numbers of Lesser Flamingo, *Phoenicopterus minor,* and the fish *Oreochromis alcalicus grahami,* which until two years ago was the only fish species found in the lake. Recent studies recorded four other tilapine species, where the most dominant species was *Oreochromis niloticus* followed by *Oreochromis variabilis, Tilapia grahami* and finally *Oreochromis leucostictus.* This is attributed to rising water levels and extremely reduced salinity of lake water. The salinity has reduced from 22–62g/l (ppt) which is optimal for growth performance of *Arthrospira fusiformis* to just 2–5g/l. This has completely changed the lake ecology, with freshwater phytoplankton such as Coccoids and zooplankton such as daphnia *magna* being dominant.

Land cover changes within the catchment of Lake Nakuru show a downward trend in forest cover and an increase in both cropland and wetland between the year 2000 and 2018. During this period, forest decreased from 8.5% to 7.7 % while cropland and wetland increased from 35.4% and 2.6% to 46.6% and 3.3% respectively (Table 7 and Figure 36). The decrease in forest cover may be attributed to conversion of forest to cropland which is evinced by steady increase in cropland. The increase in wetland on the other hand is an indication of rising levels of water in Lake Nakuru.

A snapshot from Google Earth images (Figure 37), shows the intensity of the loss of vegetation in East Mau Forest between two periods, 1973 and 2016.



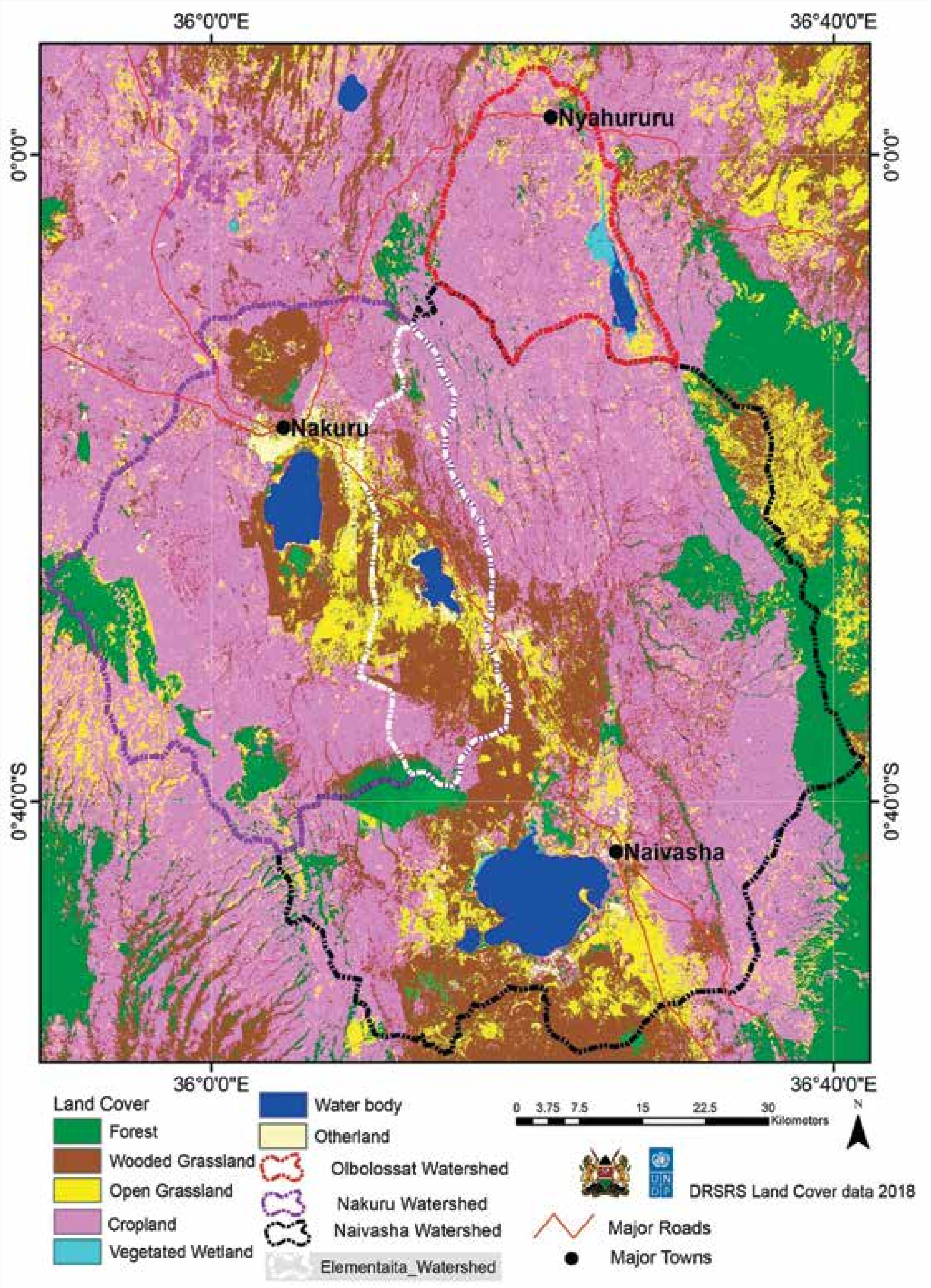


Figure 36: Land cover classes for part of the Kenya Dome covering the southern part of the dome—Lakes Naivasha, Elmenteita, Nakuru and Ol' Bolossat.

Figure 37: Devastating level of forest cover loss in the East Mau Forest area as seen in the images of 1973 and 2016

Table 7: Land cover for Lake Nakuru catchment area.

Basin Land Cover	Area (km²)	Cover	Area (km²)	Cover	Area (km²)	Cover	Area (km²)	Cover
Nakuru	**2000**	**% total**	**2010**	**% total**	**2014**	**% total**	**2018**	**% total**
Forest	192.5	8.5	156.2	6.9	208.8	9.2	174.8	7.7
Wooded Grassland	538.9	23.7	680.0	29.9	662.4	29.1	611.2	26.9
Open Grassland	661.5	29.1	554.3	24.4	444.2	19.5	293.1	12.9
Cropland	803.7	35.4	813.3	35.8	859.1	37.8	1059.5	46.6
Vegetated Wetland	0.1	0.0	0.1	0.0	1.8	0.1	1.2	0.1
Open Water	58.7	2.6	47.4	2.1	77.2	3.4	74.0	3.3
Total wetlands	58.73	2.58	47.50	2.09	79.05	3.48	75.16	3.31
Other land	18.1	0.8	22.3	1.0	20.0	0.9	59.8	2.6
Total	**2273.5**	**100.0**	**2273.5**	**100.0**	**2273.5**	**100.0**	**2273.5**	**100.0**

2.2.7 Lake Elmenteita

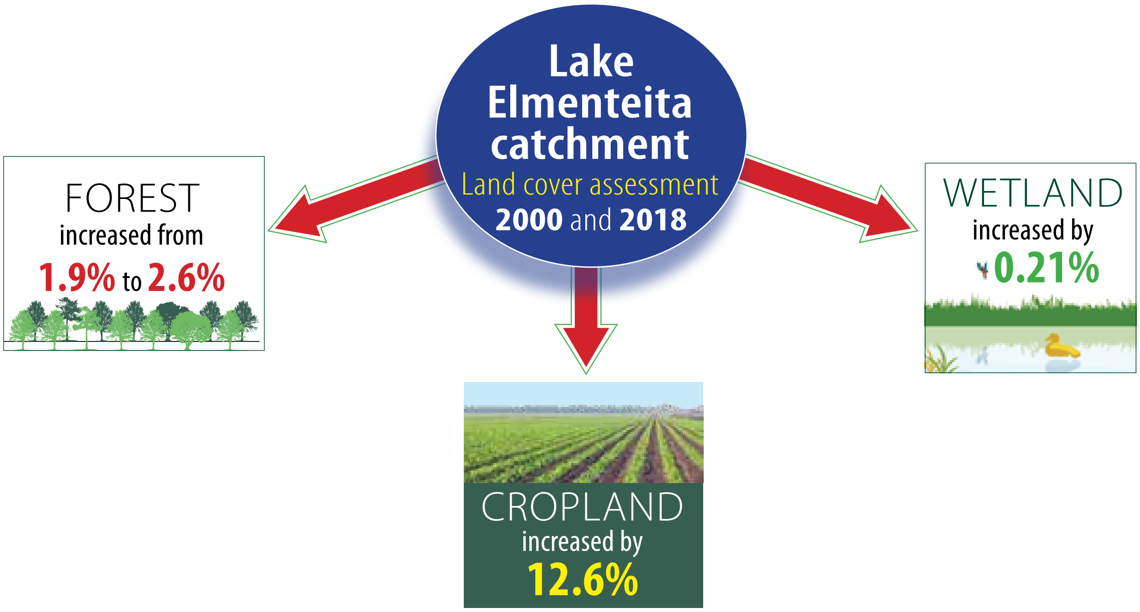
The natural vegetation around Lake Elmenteita is mainly *Acacia* and *Tarconanthus camphoratus* bushland interspersed with *Themeda triandra* grassland. Patches of *Acacia xanthophloea* woodland occur near the shore, and formerly covered a large area south of the lake. Key avian fauna include the threatened, restricted-range *Prionops poliolophus* which is found in the surrounding woodland, and *Euplectes jacksoni* which is a seasonal visitor nesting in the tall grassland. The lake consistently holds internationally important populations of Greater Flamingo, *Phoenicopterus ruber,* and Lesser Flamingo, *P. minor,* and *Recurvirostra avosetta,* which are among 69 waterbird species recorded. Fish have recently spread from the peripheral hot springs to the main lake, but even before this Elmenteita often hosted large numbers of Pelican *Pelecanus onocrotalus.*

Land cover assessment in Lake Elmenteita catchment shows an increase in forest, cropland and wetland between 2000 and 2018. Forest cover increased from 1.9% to 2.6% while cropland and wetland increased by 12.6% and 0.21% respectively (Table 8 and Figure 36). The increase in forest cover may be attributed to increased moisture within the catchment area during the assessment period. Cropland on the other hand increased at the expense of open grassland which recorded a decrease implying land conversion from open grassland to cropland. The increase in wetland signifies the rise in level of water in Lake Elmenteita.

Table 8: Land cover for Lake Elmenteita catchment area.

Basin Land Cover	Area (km²)	Cover	Area (km²)	Cover	Area (km²)	Cover	Area (km²)	Cover
Elmenteita	**2000**	**% total**	**2010**	**% total**	**2014**	**% total**	**2018**	**% total**
Forest	10.7	1.9	15.5	2.7	21.1	3.7	14.7	2.6
Wooded Grassland	193.9	34.2	270.5	47.7	276.0	48.7	260.6	46.0
Open Grassland	251.0	44.3	166.7	29.4	120.9	21.3	100.0	17.6
Cropland	88.2	15.6	94.9	16.7	123.3	21.7	159.8	28.2

Basin Land Cover	Area (km²)	Cover	Area (km²)	Cover	Area (km²)	Cover	Area (km²)	Cover
Elmenteita	2000	% total	2010	% total	2014	% total	2018	% total
Vegetated Wetland	0.0	0.0	0.1	0.0	0.4	0.1	0.2	0.0
Open Water	18.9	3.3	14.6	2.6	22.4	4.0	19.9	3.5
Total wetlands	18.94	3.34	14.67	2.59	22.77	4.02	20.13	3.55
Other land	4.3	0.8	4.8	0.8	3.0	0.5	11.8	2.1
Total	**567.0**	**100.0**	**567.0**	**100.0**	**567.0**	**100.0**	**567.0**	**100.0**



The pelicans move daily to Lake Nakuru to feed. Greater Flamingos *(Phoenicopterus ruber)* have also bred at Elmenteita in the past but have been displaced by pelicans in recent years. There have been occasional, but unsuccessful, breeding attempts by Lesser Flamingo *(Phoeniconaias minor)*. The woodland and bushland are rich in birdlife; over 400 species have been recorded, particularly raptors. Globally threatened species found in the area include *Falco naumanni*, which are mostly on transit, and vagrant *Aquila clanga and Parus fringillinus*. Regionally threatened species include *Podiceps cristatus* (which has nested here recently), *Casmerodius albus* (an important non-breeding site, with at least 50 recorded on a regular basis and as many as 156 counted in January 1994), *Trigonoceps occipitalis, Hieraaetus ayresii, Stephanoaetus coronatus, Polemaetus bellicosus, Buphagus africanus,* and *Euplectes progne*.

Soysambu Conservancy holds good populations of large mammals, including an introduced population of Rosthchild Giraffe, *Giraffa camelopardalis rothschildi*. The snake *Bitis worthingtonii*, endemic to the central Rift Valley above 1,500 m, is known to be found here. The cichlid fish, *Oreochromis alcalicus grahami*, is endemic to alkaline lakes.

2.2.8 Lake Naivasha

Lake Naivasha supports a diverse community of waterbirds, with more than 80 species regularly recorded during censuses. On average, there were 19,600 waterbirds between 1991–2001. Depending on water levels, Lake Naivasha is a significant site for *Fulica cristata* (5,050 on average between 1991–2001), *Platalea alba* (138 on average between 1991–2001) and *Tachybaptus ruficollis* (650 on average between 1991–2001). Many species of duck and Palearctic waders also found in numbers. Palearctic duck are especially abundant in November and February. Lesser Flamingos *(Phoeniconaias minor)* appear in small numbers at times, mainly on Oloidien. The lake is known for its high density of Haliaeetus vocifer, which nest in the surrounding Acacia woodland. Regionally threatened species found in the area include *Podiceps cristatus* (most recent Kenyan records are from Oloidien, with seven birds seen in January 1996), *Oxyura maccoa* (regular on Oloidien, with 170 in January 1994 and January 1997), Anhinga rufa (one recorded on Oloidien in January 1997), *Casmerodius albus* (regular at Naivasha, which is an important feeding site; 73 counted in January 1997), *Ephippiorhynchus senegalensis* (2–3 birds usually present), *Thalassornis leuconotus* (occasional; 12 counted on Oloidien in January 1994), *Porzana pusilla* (status uncertain), and *Rynchops flavirostris* (irregular visitor). Since 1995, a large nesting colony of *Phalacrocorax carbo* has established itself in the fringing Acacia woodland at Lake Oloidien. The Lake also supports a large and expanding population of *Hippopotamus amphibious* (c.300 individuals at present).

The snake *Bitis worthingtonii,* endemic to the central Rift Valley above 1,500m, is recorded in Naivasha. The fish species of lake Naivasha are all introduced from elsewhere. The only endemic fish species, the black lampeye *(Aplocheilichthys antinorii)* was last recorded in 1962. Species currently found in the lake are Nile tilapia *(Oreochromis niloticus)* introduced in 1967 and 2011, blue spotted tilapia *(Oreochromis leucostictus)* introduced accidentally in 1959, red-bellied tilapia *(Coptodon zillii)* introduced in 1959, black bass *(Micropterus salmoides)* introduced in 1927, 1949 and 1951, common carp *(Cyprinus carpio)* first recorded in 2001 and which came in through inflowing rivers, African catfish *(Clarias gariepinus),* Guppy *(Poecilia reticulate)* date of introduction unknown, Straight fin barb *(Enteromius paludinosus)* which came through in-flowing rivers, rainbow trout *(Oncorhyncus mykiss),* occasionally caught at river mouths, which came through Malewa River and freshwater prawn and Crayfish *(Procambarus clarkii),* passively introduced in 1971.

Land Cover assessment of Lake Naivasha catchment shows an increase in forest, cropland and wetland between 2000 and 2018. Forest, cropland and wetland increased by 1.1%, 17.9% and 0.34% respectively (Table 9 and Figure 36). The increase in cropland may be attributed to conversion of both wooded and open grassland into farms. It follows that both open and wooded grassland decreased significantly during the assessment period. Increase in wetland on the other hand is an indication of rising water levels in Lake Naivasha. This significantly impacted on the riparian vegetation and the settlements around the lake (Figure 38).

Figure 38: The devastating impact of the rise lake Naivasha as see in the Google Earth Images of June 2009 and Sept 2020

Table 9: Land Cover for Lake Naivasha catchment area.

Basin Land Cover	Area (km²)	Cover	Area (km²)	Cover	Area (km²)	Cover	Area (km²)	Cover
Naivasha	2000	% total	2010	% total	2014	% total	2018	% total
Forest	333.6	9.9	379.1	11.3	367.4	10.9	371.4	11.0
Wooded Grassland	920.7	27.4	919.5	27.3	964.0	28.7	836.2	24.9
Open Grassland	964.3	28.7	682.5	20.3	601.6	17.9	383.0	11.4
Cropland	988.8	29.4	1222.2	36.3	1242.8	37.0	1591.1	47.3
Vegetated Wetland	2.8	0.1	7.7	0.2	18.7	0.6	3.6	0.1
Open Water	133.3	4.0	117.6	3.5	141.9	4.2	144.1	4.3
Total wetlands	136.16	4.05	125.31	3.73	160.67	4.78	147.73	4.39
Other land	19.3	0.6	34.1	1.0	26.3	0.8	33.4	1.0
Total	**3362.8**	**100.0**	**3362.7**	**100.0**	**3362.8**	**100.0**	**3362.9**	**100.0**

2.2.9 Lake Magadi

Lake Magadi hosts the cichlid fish *Oreochromis alcalicus grahami,* which is endemic to alkaline lakes in this part of the Rift Valley and is often abundant in the hot springs. The springs also contain a highly specialized microbial fauna, with several endemic species. Several bird species are also found in Lake Magadi, most of which are concentrated in the lagoons. Lesser Flamingo *(Phoenicopterus minor)* is often present in internationally important numbers (an average of 23,250 between 1994–2001). Very large numbers of this species may breed here on rare occasions, perhaps once a century—the last such event was recorded in July 1962, when over a million pairs nested. Other varieties of waterbirds are present, including a sizeable resident population of *Charadrius pallidus* (an average of 420 between1994–2001).

Other birds nesting at Magadi include *Platalea alba, Anas capensis, Recurvirostra avocetta* and *Himantopus himantopus*. Palearctic birds migrate to Magadi during winter, *Calidris minuta* being an example. The bushland around the lake supports 28 of Kenya's 94 Somali–Masai biome species. *Casmerodius albus,* a regionally threatened species, is an occasional visitor.

Assessment of changes in land cover in Lake Magadi catchment area between 2000 and 2018 shows a steady decrease in forest, grassland and wetland. Forest cover decreased from 11% to 7.3% while wooded and open grassland decreased from 59.4% and 23.2% to 55.8 and 22.4% respectively. Wetland on the other hand decreased by 0.03% (Table 10 and Figure 40). Cropland was the only land cover that registered an increase within the catchment, by 8.2%. The decrease in both open and wooded grassland means loss of grazing and browsing fields for pastoral communities who dominate the catchment. This is also an indication of land degradation within the catchment as it increases the rate of more run-off, soil erosion and deposition of silt to the lake reflected in the solution of the soda ash in the lake (Figure 39).

Table 10: Land cover for Lake Magadi catchment area.

Basin Land Cover	Area (km^2)	Cover	Area (km^2)	Cover	Area (km^2)	Cover	Area (km^2)	Cover
Magadi	2000	% total	2010	% total	2014	% total	2018	% total
Forest	1855.0	11.0	1583.2	9.4	1421.3	8.4	1228.8	7.3
Wooded Grassland	10034.9	59.4	9563.5	56.6	9622.7	57.0	9422.6	55.8
Open Grassland	3923.9	23.2	3682.3	21.8	4026.1	23.8	3790.0	22.4
Cropland	825.0	4.9	1817.3	10.8	1573.7	9.3	2219.2	13.1
Vegetated Wetland	1.2	0.0	2.0	0.0	3.7	0.0	3.5	0.0
Open Water	101.0	0.6	87.2	0.5	101.1	0.6	94.0	0.6
Total wetlands	102.19	0.61	89.15	0.53	104.73	0.62	97.45	0.58
Other land	145.9	0.9	150.5	0.9	138.5	0.8	128.0	0.8
Total	**16887.0**	**100.0**	**16886.0**	**100.0**	**16887.0**	**100.0**	**16886.0**	**100.0**

Figure 39: Trona harvesting ponds in Lake Magadi and solution of soda ash due to increased run-off input seen in Google Earth image of Sept 2014 compared to Dec 2017

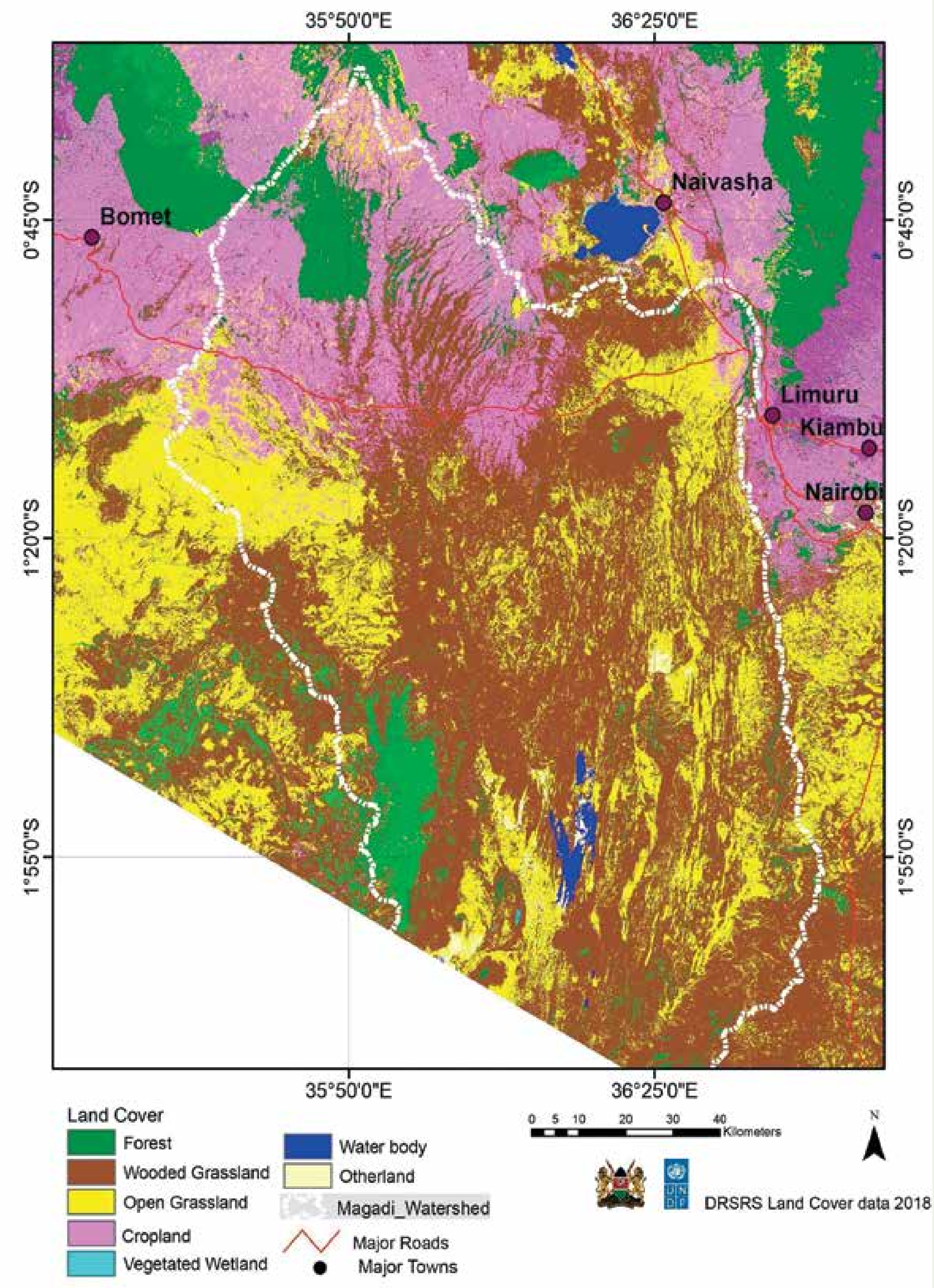


Figure 40: Land cover map of Magadi Basin which also served by has the South Mau forest.

2.2.10 Lake Victoria

The Lake Victoria basin is rich in biodiversity although natural habitats are under threat from rapidly increasing human population. Biodiversity in the main lake consists of fish species, birds and higher vertebrates like amphibians, reptiles and mammals as well as several plant species. Others include algae (phytoplankton) and invertebrates (zooplankton). Loss of habitat for a total of 44 mammalian species has been recorded in the lake. These are found in conservation areas like Ndere Island National Park and Impala Wildlife Sanctuary and in the surrounding wetlands. Mammals include Hippos, the threatened aquatic Sitatunga, antelopes, zebras, and warthogs, Aardvark, Monkeys, Baboons, and Waterbucks.

Over 100 species of birds including the fish eagle, Hammerkop, Goliath heron, Egrets, Kingfisher, Gonolek, Jacana, and 31 species of amphibians such as frogs and toads inhabit the lake. 28 reptilian species such as Nile crocodile *(Crocodylus niloticus),* monitor lizard, Green mambas, and Puff adder are found there. There are various Zooplanktons in the lake that consist of micro-invertebrates including 11 species of Copepods, 6 Species of Rotifers, Cladorerans, Chironomids, and various species of macro-invertebrates. The effluent and silt have created a conducive environment for growth of lake water plants like hyacinth, hippo-grass, and planktons. Fish biodiversity in Lake Victoria is dominated by the native haplochromine species that once registered 500 subspecies. However, during the 1950s and 1960s, the colonial administration introduced several species to boost fisheries. These included tilapiines: *O. niloticus, O. leucostictus, Tilapia rendalii* and *C. zillii;* and Nile perch, *Lates niloticus*. There are also groups of noncichlids fishes, including *Protopterus aethiopicus, Bagrus docmak, Clarias gariepinus, Schilbe intermedius, various Barbus* species and mormyrids. Currently, about 200 species of fish inhabit the lake and the lake basin.

Land cover assessment within Lake Victoria catchment areas between 2000 and 2018 shows an increase in forest, cropland and wetland. Forest cover increased by 1.1% while cropland and wetland increased by 21.6 and 0.04% respectively (Table 11 and Figure 43). The increase in forest cover may be due to enhanced conservation efforts by the government which led to restoration of water towers such as Mt. Elgon, the Cherangany Hills and the Mau Forest Complex, which are the main catchments of Lake Victoria. This is also evidenced by the increased precipitation, increased flow of rivers, the rising levels of lake water and submersion of coastline developments as seen in the Google Earth image of Homa Bay area sewerage treatment works (Figure 41). Much of the urban settlement along the lake is not compliant with the requirements for the management of riparian lands set out by NEMA, as seen in the example of the image of Mbita Point at Mbita Causeway and Island (Figure 42).

Table 11: Land cover for Lake Victoria drainage basin area.

Basin Land Cover	Area (km²)	Cover	Area (km²)	Cover	Area (km²)	Cover	Area (km²)	Cover
Victoria	2000	% total	2010	% total	2014	% total	2018	% total
Forest	4707.4	9.4	4797.9	9.6	5090.6	10.2	5243.2	10.5
Wooded Grassland	9158.6	18.3	6762.3	13.5	6696.9	13.4	6002.9	12.0
Open Grassland	13433.2	26.9	8203.4	16.4	8514.9	17.0	5145.2	10.3
Cropland	18658.3	37.3	25962.7	52.0	25433.4	50.9	29451.0	58.9
Vegetated Wetland	112.6	0.2	320.5	0.6	189.2	0.4	132.7	0.3
Open Water	3795.0	7.6	3765.9	7.5	3788.8	7.6	3795.2	7.6
Total wetlands	3907.58	7.82	4086.38	8.18	3978.01	7.96	3927.94	7.86
Other land	108.5	0.2	161.0	0.3	259.8	0.5	203.4	0.4
Total	**49973.6**	**100.0**	**49973.7**	**100.0**	**49973.6**	**100.0**	**49973.6**	**100.0**

Figure 41: Google Earth Image extract of Homa Bay Sewerage treatment ponds showing poor siting of the ponds and the extent of submergence of from Lake Victoria level rise lading to direct contamination of Lake waters

Figure 42: Mbita Causeway and Island area as seen in urbanization contrasting images of March 2000 and February 2020.

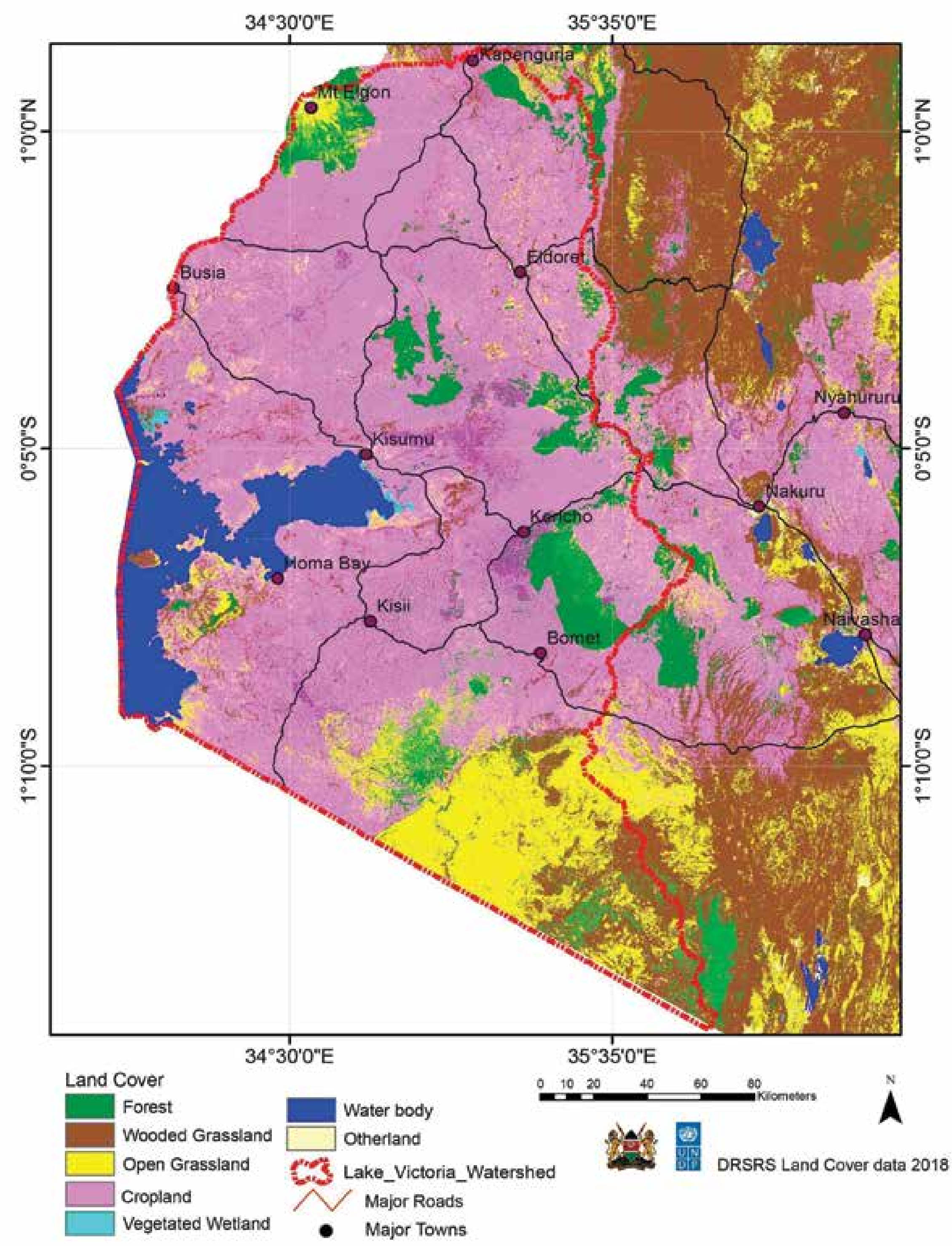


Figure 43: Land Cover map of Lake Victoria Basin where 58.9% of the area is under cropland and thus is heavily settled.

2.3 Development Infrastructure

The recent rising water levels in the rift valley lakes and Lake Victoria have had massive negative impacts on infrastructural developments. A lot of properties such as roads, hotels, schools, businesses, and houses have been destroyed, the extent of which is summarized in Table 12 below:

Table 12: Impacts on Development Infrastructure.

S/N	Lake	Impacts on Development Infrastructure
1	**Lake Turkana and Turkwel Dam**	• 64 boats destroyed on lake Turkana. • 9 boats destroyed on Turkwel Dam. • Most of St Kelvin's school infrastructure submerged. • Destruction of the sewage system. • Water level monitoring stations have been washed away or submerged. • 5000 households flooded. • 4 worship centres destroyed. • 35 km of road networks have been destroyed. • 16 borehole facilities have been submerged. • A number of health facilities have been submerged. • 350 households in Layeni and El Molo villages affected. • Fish and storage facilities in Loinyangalani submerged. • 250 Households in Ileret on the Ethiopian border displaced twice. In Turkana Central, Sub-County the following schools were flooded: • Ngimuriea Primary School • Nangitony Primary School • Merierg Primary School • St. Mark's Elelea Primary School • Longech Primary School • Namukuse Primary School • Kalimapus Primary School • Natale Primary School
2	**Lake Baringo and Lake Bogoria**	• Noosukuro Primary School submerged. • Ngambo Primary School require relocation. • Kiserian Primary School require relocation. • Loruk Low Cost Boarding require relocation. • Kiserian Boys Secondary School require relocation. • Salabani Mixed Day and Boarding Secondary Schools require relocation.

S/N	Lake	Impacts on Development Infrastructure
2		• Lake Baringo Secondary School require relocation. • Ngambo Girls Secondary School require relocation. • GSU-RDU camp submerged. • Noosukuro shopping centre has been destroyed. • Rugus Ndogo village electricity lines have been partly submerged. • Loboi and Kambi Samaki health facilities destroyed. • Papyrus Inn hotel has had 20 rooms destroyed. • Lake Bogoria Curio, Bar and Restaurant submerged. • 2 health facilities in Loboi and Kambi Samaki are totally submerged. • Papyrus Inn, a well-known hotel of about 18 to 20 rooms, has been submerged.
3	**Lake Solai**	• The playground for Ngendaptich Primary School has been destroyed.
4	**Lake Ol' Bolossat**	• Lake Ol' Bolossat did not experience any massive negative impacts on development infrastructure.
5	**Lake Nakuru**	• 151 houses and 352 households in Mwariki area affected. • KWS Administrative block and some residential buildings submerged. • KWS campsites have been submerged. • 20 km circuit Roads have been submerged. • A 26 km electric perimeter fence has been submerged.
6	**Lake Elmenteita**	• Lake Elmenteita did not experience any destruction on development infrastructure.
7	**Lake Naivasha**	• 500 homes submerged. • Kamere Public Beach, including business premises, submerged. • An estimate of 500 homeowners were displaced and their homes destroyed by the rising water levels in the Kihoto area.
8	**Lake Magadi**	• Lake Magadi did not witness any destruction on development infrastructure.
9	**Lake Victoria**	In Migori County - *Fish farms totaling 207 (20.2 acres) destroyed by floods:* • Muhuru Bay and Sori fish landing bandas destroyed. • Sere Primary School need rehabilitation • Angugo Primary School need rehabilitation • Nyora Primary School need rehabilitation

S/N	Lake	Impacts on Development Infrastructure
		• Modi Primary school need rehabilitation • Areko Primary School need rehabilitation • Angugo Secondary School need rehabilitation • Modi Secondary school need rehabilitation • 10,000ha of Lower Kuja Irrigation Scheme flooded. • 6,901 ha of cropland flooded. • 5 informal landing beaches have been destroyed.
		In Homabay County - *Fish farms totaling 549 (48.6 acres) destroyed by floods:* • 1,800 ha cropland flooded. • 137 landing beaches destroyed, of which65 require rehabilitation. • White Stone Resort, Rusinga Island Resort and Rusinga Lodge were partially submerged. • 1,800 acres of rice paddy destroyed. • At least 300 m of road networks fully submerged. • Oluch Kimira, a gravity feed irrigation scheme with over 1,400 ha, was partially submerged.
		In Kisumu County - *Fish farms totaling 342 (30.4 acres) destroyed by floods:* • Kandaria Primary School need relocation • Oseth Primary School need relocation • Ogenya Primary School need relocation • Kandazia Secondary School need relocation • Nyamurundu Primary School need relocation • Kibarwa Primary School need relocation • Odienya Primary School need relocation • Odienya Secondary School need relocation • 27,567ha of cropland flooded in the West Kano Irrigation Scheme. • 1,800 acres of rice paddy destroyed in West Kano Irrigation Scheme. • Impala Eco Lodge submerged. • 4.7 km^3 of Kisumu Golf field submerged.
		In Siaya County - *Fish farms totaling 548 (44.6 acres) destroyed by floods:* • Dykes destroyed at the Dominion Farms (Yala Swamp Irrigation Scheme) • Roads submerged. • About 120 houses submerged. • Electric poles submerged. • More than 10 landing beaches and bandas submerged.

S/N	Lake	Impacts on Development Infrastructure
		In Busia County - *Fish farms totaling 506 (3$.5 acres) destroyed by floods:* • Budala Primary School submerged. • Bulwani Primary School submerged. • Buongo Primary School submerged. • Musoma Primary School submerged. • Musonia Primary School submerged. • Maduwa Primary School submerged. • Runyu Primary School submerged. • Osieko Primary School submerged. • Musoma and Osieko Secondary Schools were submerged • The Governor's office in Bunyara South submerged. • Transformers and electric poles submerged. • Roads connecting Mau Mau village and the neighbouring communities have been submerged. • 5 fish landing beaches destroyed. • Rice crop in about 2,000 acres at Bunyala Irrigation Scheme completely submerged.

3 Causes of Rising Lake Water Levels

3.1 Hydro-meteorological and Climatic Causes

3.1.1 Rainfall

Kenya experiences bimodal rainfall seasons with long rains received in the March to May (MAM)) season and short rains received in the October to December (OND) season. The January to February period is usually hot and dry while the June to August (JJA) season is usually cool and dry even though it is becoming one of rainy seasons in western part of Kenya due to climate change.

In the year 2019, Kenya generally received higher rainfall than the long-term mean with the OND season experiencing one of the highest ever recorded rainfall only comparable to that in the years 1961 and 1997 (Figure 44).

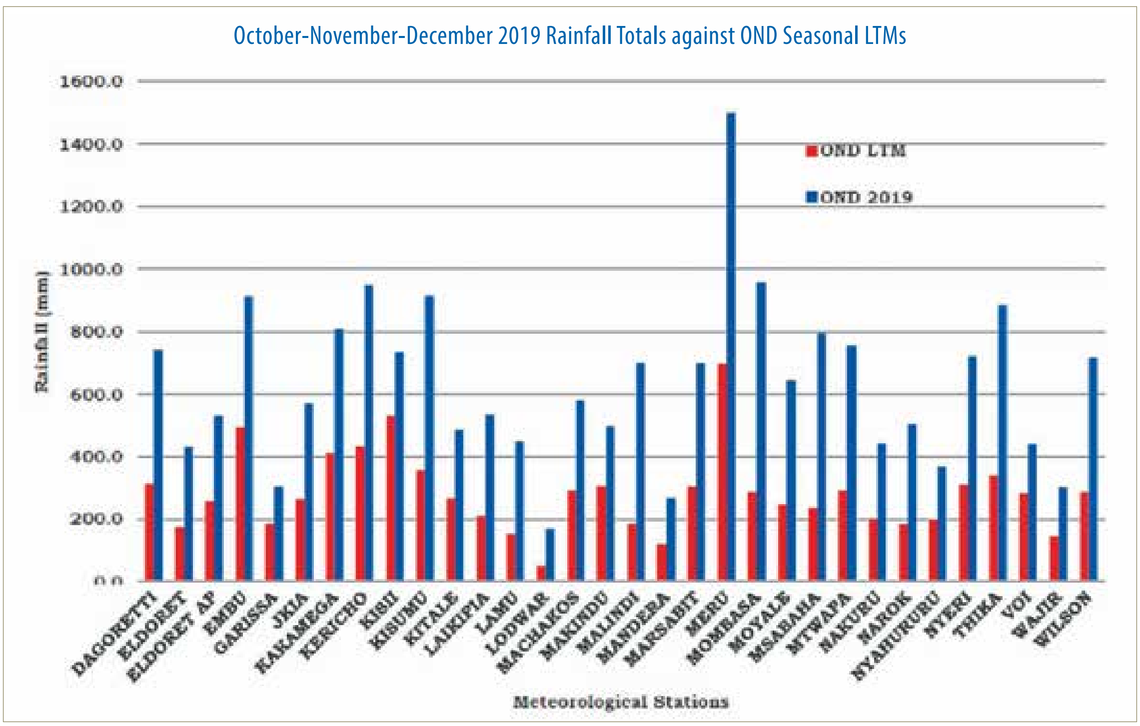


Figure 44: OND 2019 Rainfall Totals (State of Climate in Kenya, 2019).

June to August (JJA) is a significant season for the western and coastal regions of the country. Areas in Central Rift Valley, Lake Basin and the Coastal regions receive significant amounts of rainfall during this season (Figure 45).

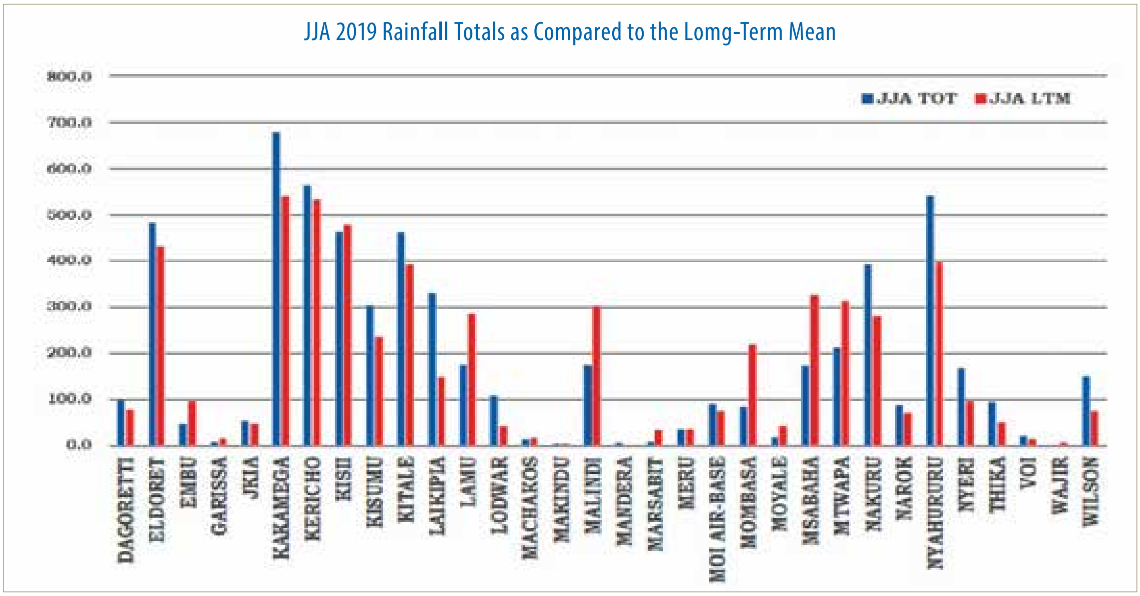


Figure 45: JJA 2019 Rainfall Totals (State of Climate in Kenya, 2019).

The rainfall recorded during MAM 2019 indicates that the rainfall performance was generally poor in most parts of the country (Figure 46). Most regions remained generally sunny and dry. Seasonal rain started late in most parts, and even so, it was spatially and temporally unevenly distributed.

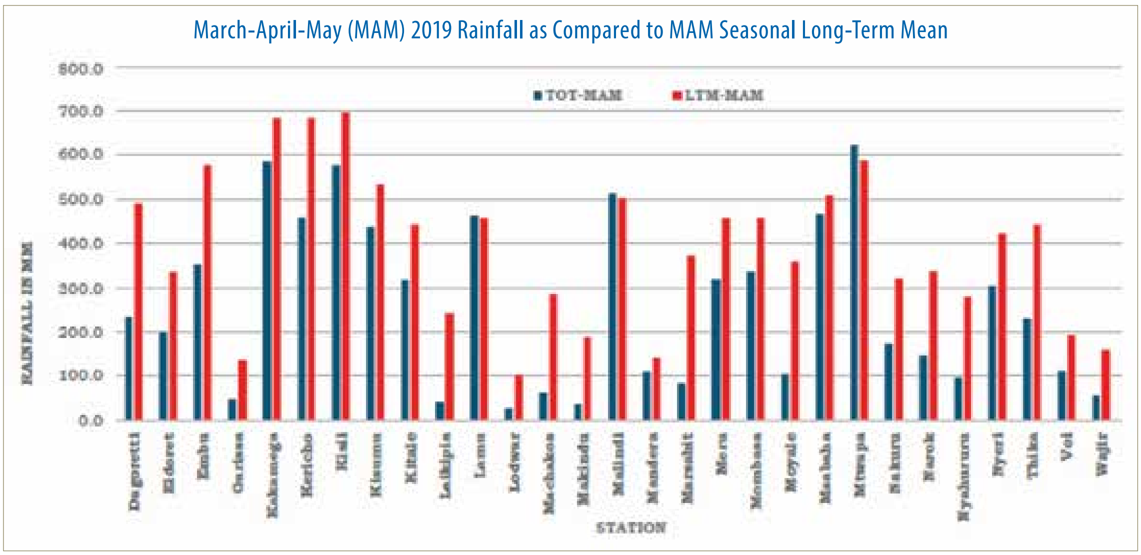


Figure 46: MAM 2019 Rainfall Totals (State of Climate in Kenya, 2019).

3.1.2 River Discharges and Water Levels in the Lakes and Dams

3.1.2.1 Lake Turkana

Lake Turkana is a major physiographic feature in the north rift part of the Great Rift Valley of Eastern Africa. The lake lies approximately between latitude 3°35′N and longitude 36°7′E where the Rift Valley graben is at its widest, about 100 km. The lake which is about 30 km wide and 265 km long, receives water from three major rivers one of which is the Omo River sourced from the Ethiopian highlands. The total drainage basin of lake Turkana is 149,069 Km^2. The Omo River contributes about 90% of the recharge into the Lake. Turkwel and Kerio rivers contribute the remaining 10% despite these two rivers covering 30% of the Lake Turkana basin area. In total, the Turkwel Gorge Drainage Basin area and Kerio catchment area draining into the lake is 41,700 km^2.

3.1.2.2 Turkwel Dam

Turkwel Dam is an arch dam on the Suam River about 76 km North of Kapenguria in West Pokot County, Kenya. The dam lies within Latitude 1°53′53.47″N and Longitude 35°20′1.34″E. With a capacity of 1.6 billion cubic metres, the dam serves several purposes which include hydroelectric power production, irrigation, tourism and fisheries. It was constructed between 1986 and 1991. It supports hydroelectric power plants with an installed capacity of 106 MW.

Suam river originates from the Ugandan side of Mount Elgon and joins Turkwel River before draining into Lake Turkana, the largest desert lake in the world which covers a total catchment area of 23,740 km^2. The Turkwel Dam water catchment area is 5900 km^2 in size, 67% of it being in Kenya while the remaining 33% is in Uganda. Inflows into the Turkwel dam vary significantly throughout the year, ranging between less than $1m^3$/sec to over $500m^3$/sec (Figure 47). Water levels in the dam steadily rose from July 2019 and reached a historic high level of 1148.36 m asl. on 1 November 2020 (Figure 48).

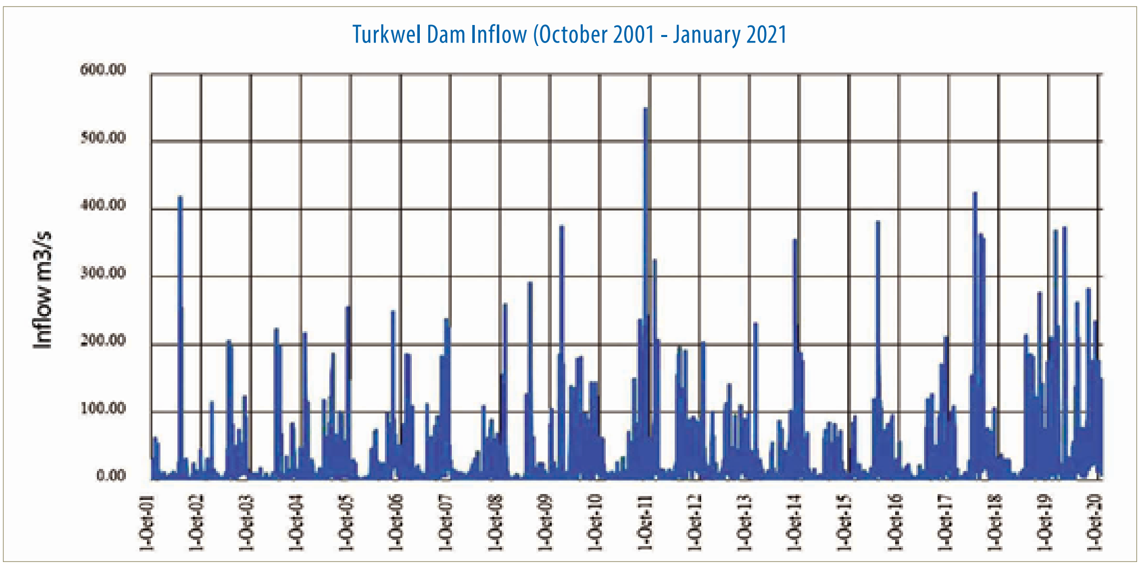


Figure 47: Inflows into Turkwel Dam

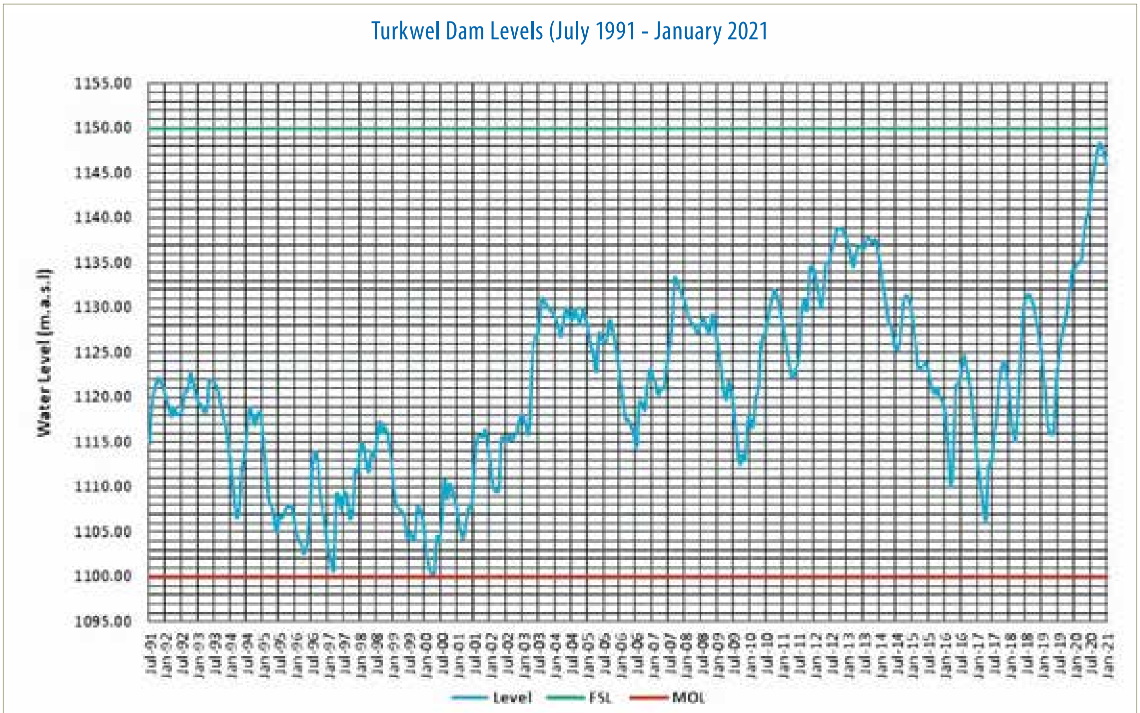


Figure 48: Turkwel Dam water levels

3.1.2.3 **Lake Baringo**

Lake Baringo has an estimated surface and catchment areas of approximately 130 km^2 and 6,820 km^2 respectively, and a mean depth of 5.9m and approximately a maximum depth of 10m. Its waters remain fresh despite its shallow depth, the high net evaporation that characterizes the rift floor, and the absence of a surface outlet. Recent hydrogeological evidence confirms that some lake water is lost by underground seepage through the fractured floor of the lake. The climate of the area is arid to semi-arid with dry and wet seasons that are unpredictable and irregular. Lake Baringo experiences remarkably high annual evaporation rates of 1650–2300 mm and its persistence depend on the inflows from rivers originating from the surrounding escarpments of Tugen hills, Marmanet-Laikipia, Bahati Escarpment and the northern parts of Mau escarpment where Molo River originates. The river flows from River Perkerra and River Molo indicate increased flows from 2019 (Figure 49 and Figure 50).

Its waters remain fresh despite its shallow depth, the high net evaporation that characterizes the rift floor, and the absence of a surface outlet

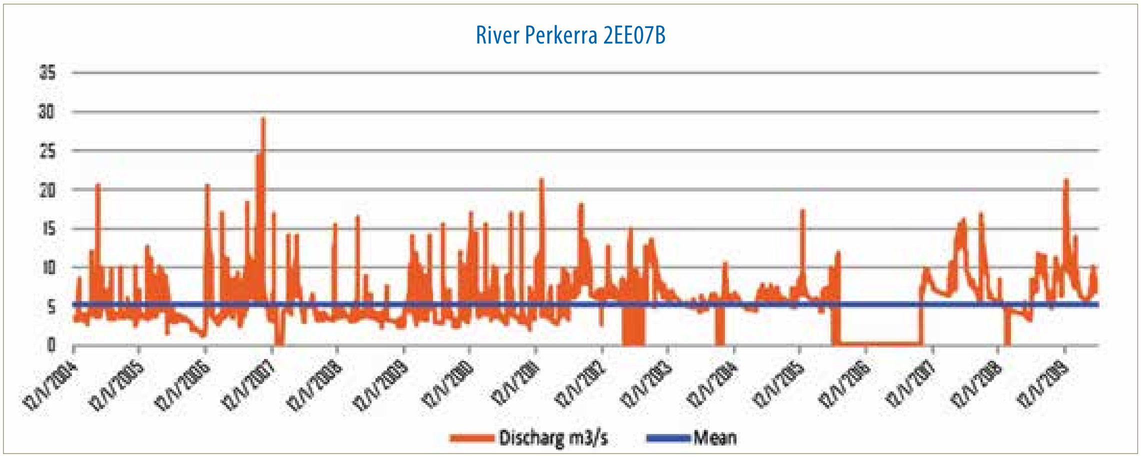


Figure 49: Perkerra River flows between 2004 and 2020.

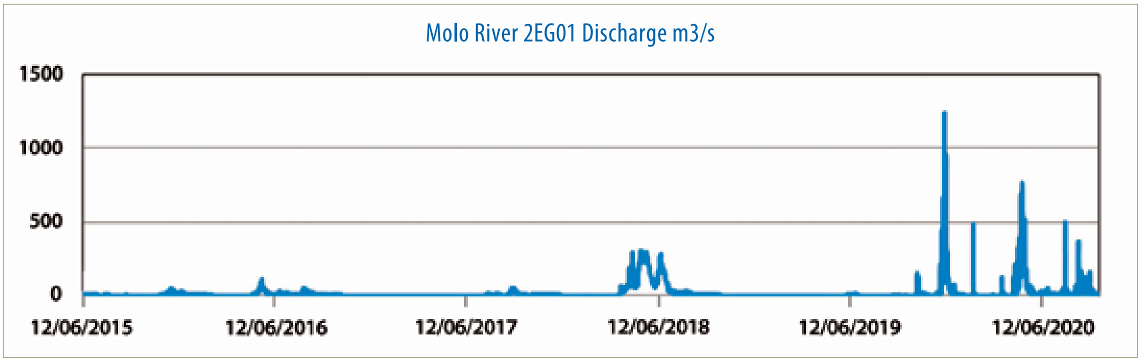


Figure 50: Molo River flows between 2015 and 2020.

From November 2019, the water levels in Lake Baringo have also risen steadily in tandem with increased rainfall and inflows (Figure 51).

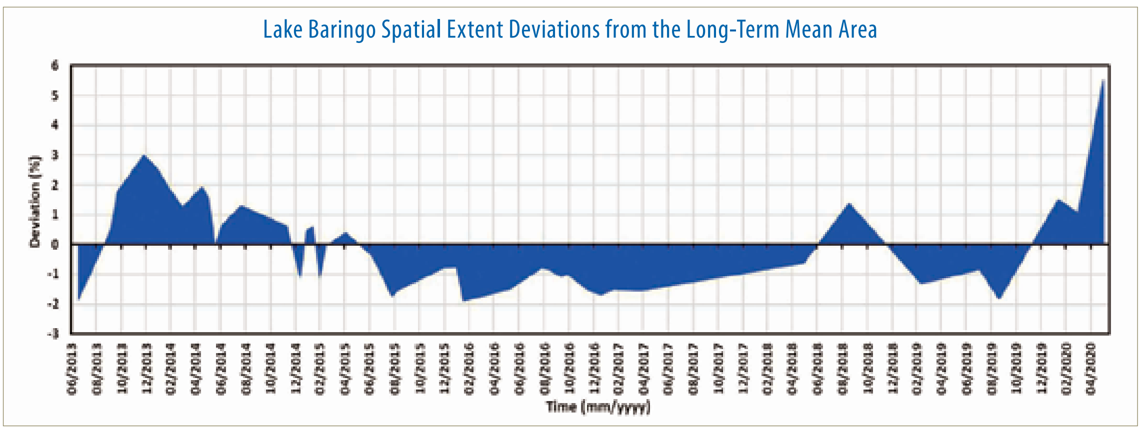


Figure 51: Lake Baringo Spatial Extent Deviation from Long-Term Mean.

3.1.2.4 **Lake Bogoria**

Lake Bogoria has a mean spatial area of about 39 km^2 and altitude of about 960m above the sea level. Its catchments have a mean annual rainfall of about 1000mm. The lake is situated less than 20 km from Lake Baringo.

The rivers draining to Lake Bogoria include Waseges, Sandai, Loboi, Emsos and Mogun. The Waseges River, which flows from the Nyandarua Plateau and enters the lake from the northern edge, changes its name to Sandai River in the section between the escarpment and the lake. Flows from Subukia River, a tributary of Waseges River, are steadily increasing (Figure 52).

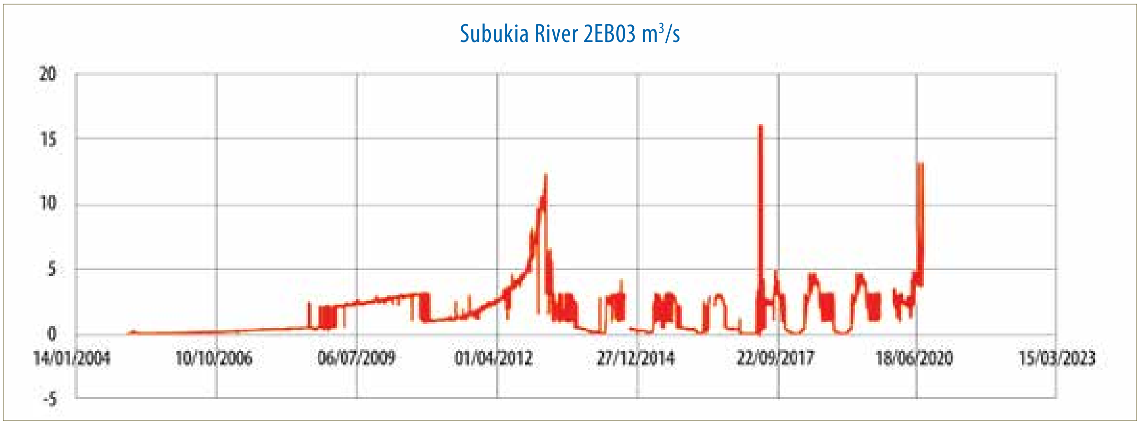


Figure 52: Subukia River Discharges between 2004 and 2020.

The rising water levels in Lake Bogoria are a response to the high rainfall received during the OND rainfall season which generated increased inflows into the lake from the rivers/streams draining into the lake (Figure 53).

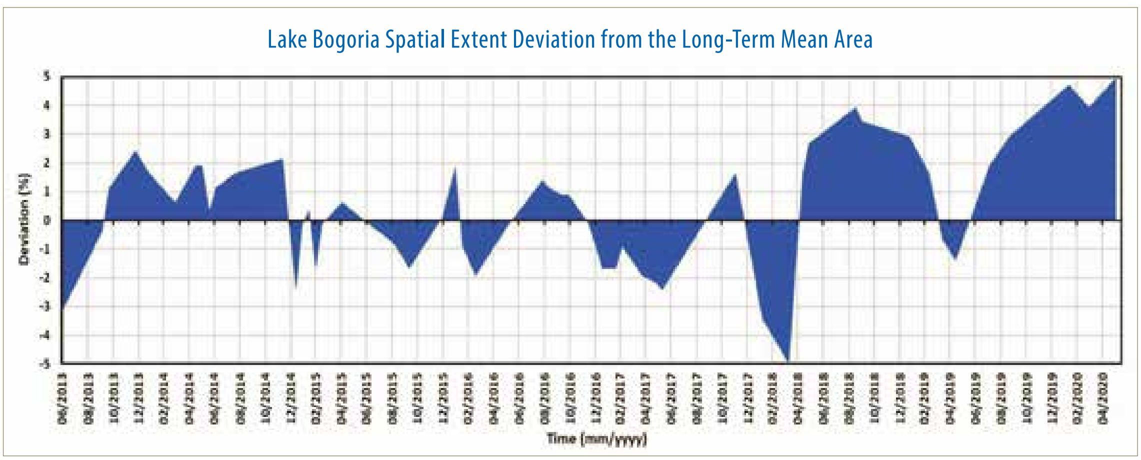


Figure 53: Lake Bogoria Spatial Extent Deviation from Long-Term Mean.

3.1.2.5 **Lake Solai**

Lake Solai is located 50 km North of Nakuru town in Nakuru County. The lake is bordered by Subukia escarpment to the East and a fault line to the West and lies at an altitude of about 1,500m above sea level with a maximum depth of 1 meter. Lake Solai covers an area of 8 km^2. Lake Solai has a comparatively smaller catchment area when compared to Lake Nakuru. Its catchments include Menengai, Chesebet Hills and Bahati Escarpment. The lake is fed by seasonal streams. Major input of water into the lake is through precipitation and surface run-off while water loss is mainly through evaporation caused by high temperatures.

3.1.2.6 **Lake Ol' Bolossat**

Ol' Bolossat is surrounded by Ndaragwa, Ol Kalou and Ol Joro Orok Sub counties. It is situated in a wedge-shaped floor of the Rift Valley sloping eastwards and northwards, known as Ongata Pusi. Lake Ol' Bolossat is approximately 195 km north of Nairobi. The lake has a surface area of about 43 km^2 and lies at an average altitude of 2340m above the sea level.

The lake is the largest water mass in Nyandarua County and is fed by streams and underground water seepage from the Aberdare and Dundori hills with a catchment area covering 4,800 km^2. There is seasonal inflow of water from streams in the eastern side as well as underground springs that replenish the lake from the western side. Most streams flow for a distance and then disappear underground recharging the Lake as subsurface flow. Since the 1997–1998 *El Nino* rains, the lake has been receiving substantial inflows (Figure 54) that has contributed to the rising water levels in the lake.

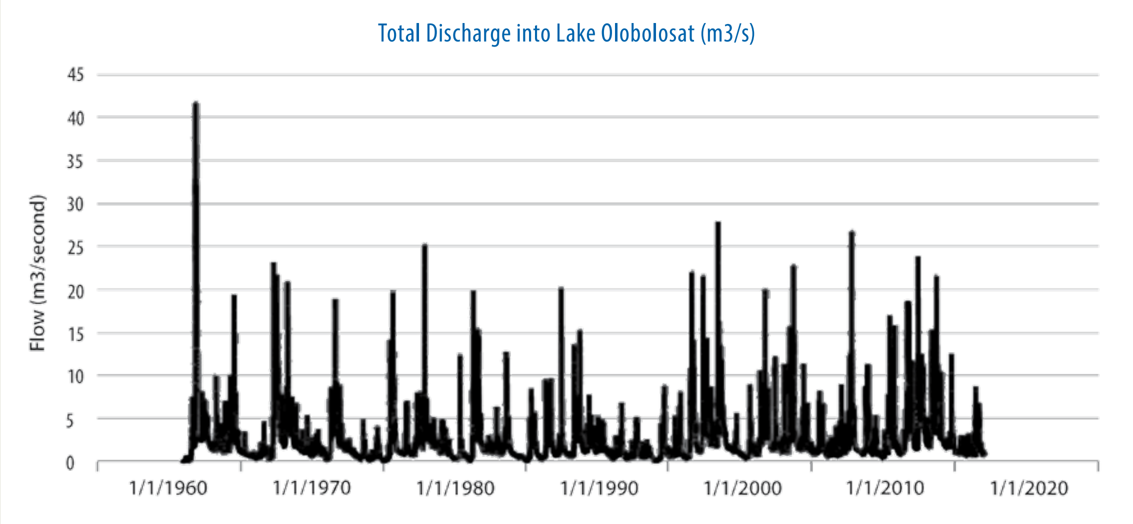


Figure 54: Ewaso Nyiro North River Discharges from 1961 to December 2016.

3.1.2.7 **Lake Nakuru**

Lake Nakuru is one of the soda lakes Rift Valley. It is located 1,754 m above sea level and has a mean surface area of about 47 km^2 and catchment areas of about 1,760 km^2. It is protected by Lake Nakuru National Park and contains high concentrations of algae that attract a large number of flamingos that line the shores of the lake and for which the lake is famous for. However, since 2012, conditions have become unfavourable for the birds which have now migrated leaving only a small population seen on the southern shores of the lake.

High inflows into the lake since 2010 to date (Figure 55) have resulted in the steadily rising levels of water Lake Nakuru.

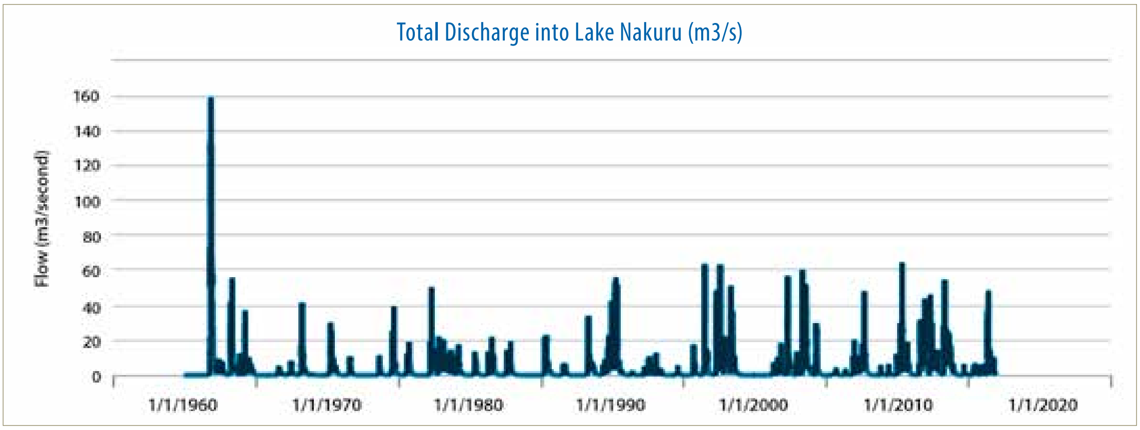


Figure 55: Inflows into Lake Nakuru

Water drainage into Lake Nakuru has gradually increased from 2010. However, for lake Nakuru catchment, there was a higher runoff in 1997–1998 during the El Niño rains, in 2003, and then as from 2010. Since 2010, the runoff has surpassed the average daily inflow of 2.615 m^3/sec into the lake. Njoro River, one of the main rivers draining into Lake Nakuru, has exhibited high discharges from the MAM 2018 season to date (Figure 56).

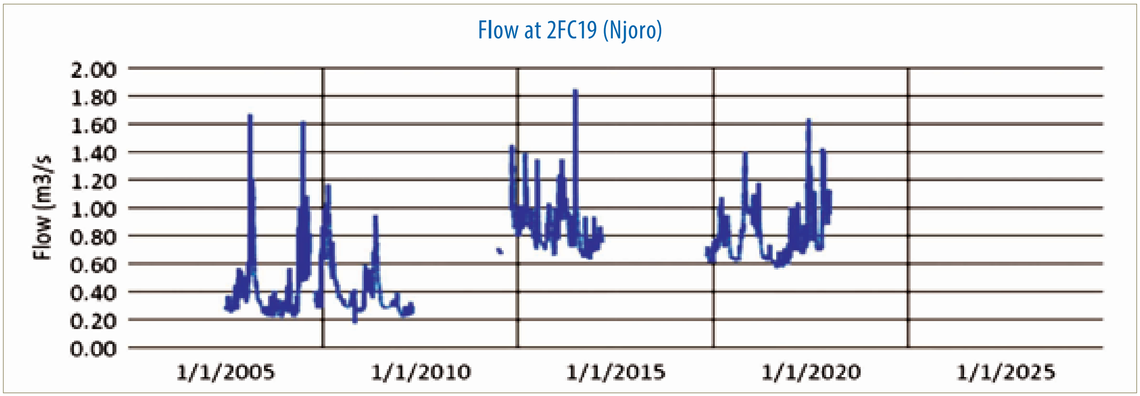


Figure 56: Njoro River Discharges.

Due to its location in a basin without surface outlets, the lake is subject to considerable fluctuations water levels. In extreme moments, the lake can dry out. On the other hand, Lake Nakuru was the first of the Rift Valley lakes to burst its bank. The lake increased its flood area from a low of 31.8 km^2 in January 2010 to a high of 65 km^2 in October 2020, an increase of 34.9 km^2 (Figure 57).

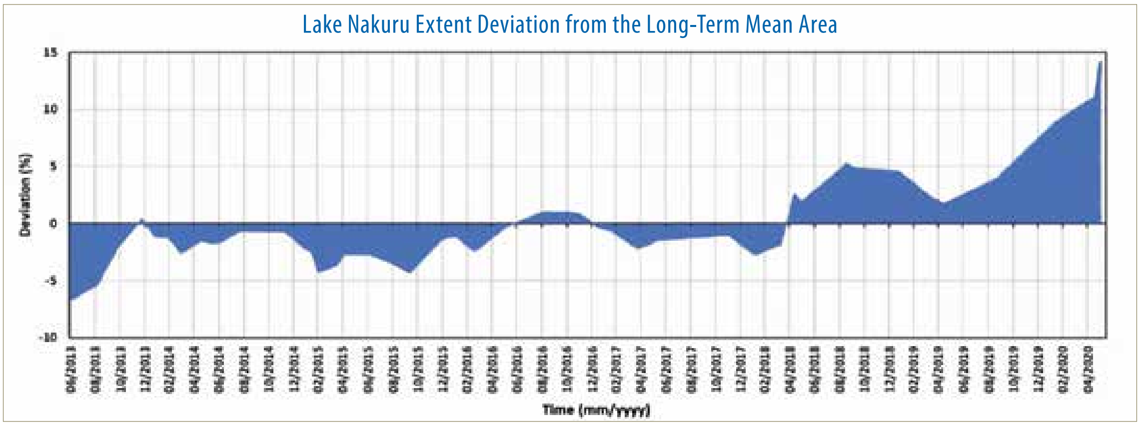


Figure 57: Lake Nakuru Spatial Extent Deviation from Long-Term Mean.

3.1.2.8 **Lake Elmenteita**

Lake Elmenteita was designated as the fifth Ramsar site in Kenya in 2005 when it was listed as a wetland of international importance due to its role as a refuge for threatened, vulnerable and endangered bird species. Lake Elmenteita and its surrounding riparian lands were also proclaimed a National Wildlife Sanctuary in 2010. In 2011, Lakes Elmenteita, Nakuru and Bogoria were all inscribed by UNESCO as part of the Kenya Lakes System in the Great Rift Valley Heritage Site.

Major tributaries include Kabugi, Gitare, Kekopey and Mai-Mahiu. Changes in lake water levels between 2010 and 2020 depict increasing water levels submerging a large area surrounding the lake. The inflows into Lake Elmenteita between 1960 and 2016 explain to the steadily rising level of the lake (Figure 58).

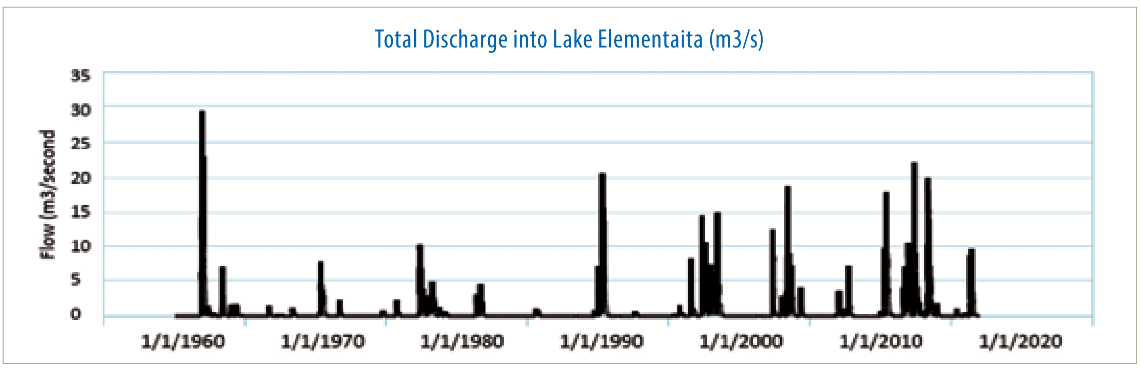


Figure 58: Inflows into Lake Elmenteita

3.1.2.9 **Lake Naivasha**

Lake Naivasha is a freshwater lake located at the highest point in the Kenyan Rift Valley1,884 m above the sea level. It has a surface area of about 139 km^2 and catchment area of about 2,380 km^2. Apart from several transient streams, the lake is fed by the perennial Malewa and Gilgil rivers (Figure 59). The lake has no visible outlets, but it is assumed to have an underground outflow which keeps the water relatively fresh.

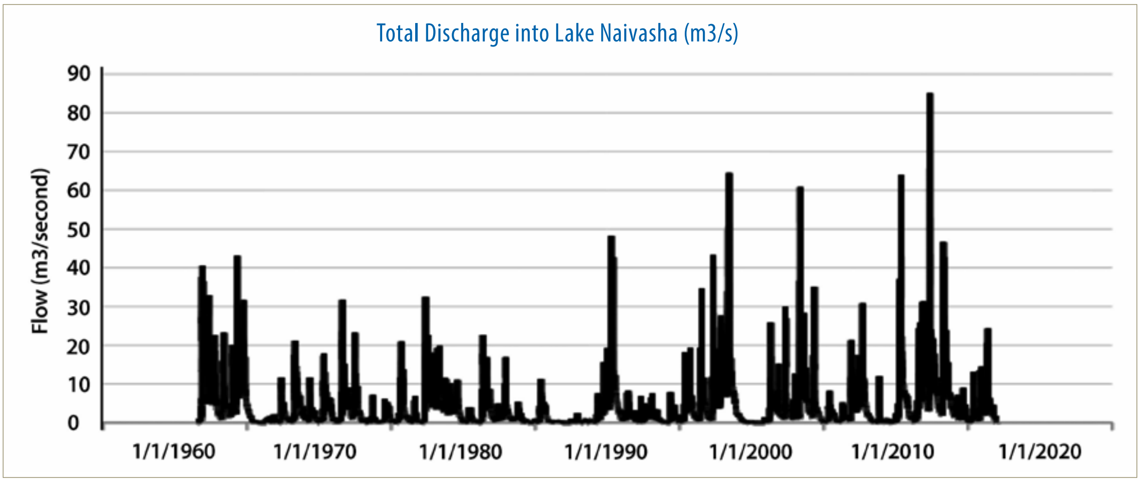


Figure 59: Inflows into Lake Naivasha.

The increased flows of water into the lake have led to the rising water levels. The surface area of the lake has significantly increased from 112.66 km^2 in 2010 to 173 km^2 in 2020, a variance of 60.34 km^2 (Figure 60).

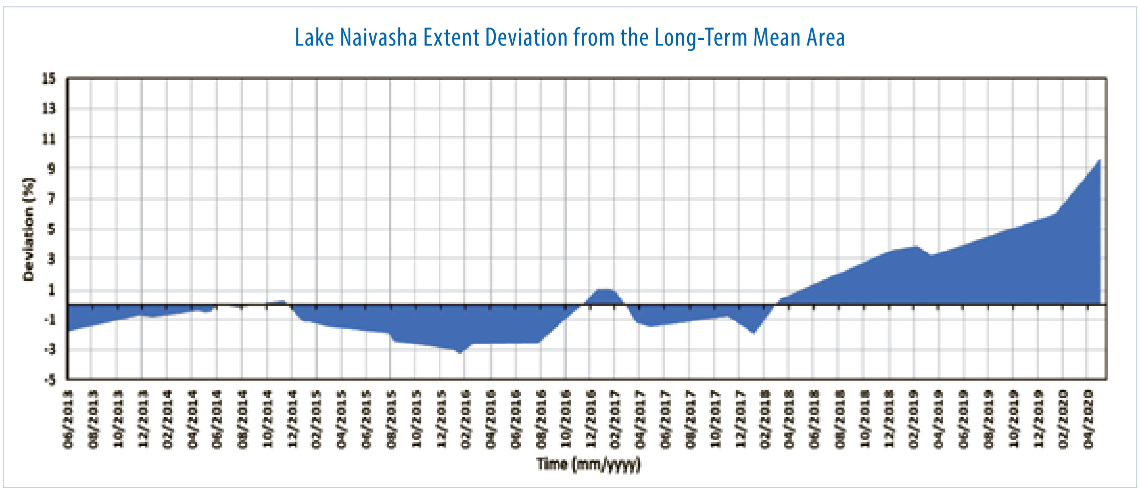


Figure 60: Lake Naivasha Spatial Extent Deviation from Long-Term Mean.

3.1.2.10 **Lake Magadi**

Lake Magadi is the southernmost lake in the Kenyan Rift Valley, lying in a catchment of faulted volcanic rocks north of Tanzania's Lake Natron. The lake is a shallow alkaline lake largely covered by crusts of sodium carbonate. It is located 85 km south-west of Nairobi in a low-lying basin on the floor of the Rift Valley. Extensive surface water is present only after heavy rains over the local catchment, when run-off reaches the northern end of the lake via three wadis. Most of the lake is a vast expanse of solid sodium carbonate (trona) and allied salts, some 15–30 m thick. This is mined by the Tata Chemicals Magadi Company, whose factory and associated town are on the north-eastern shore.

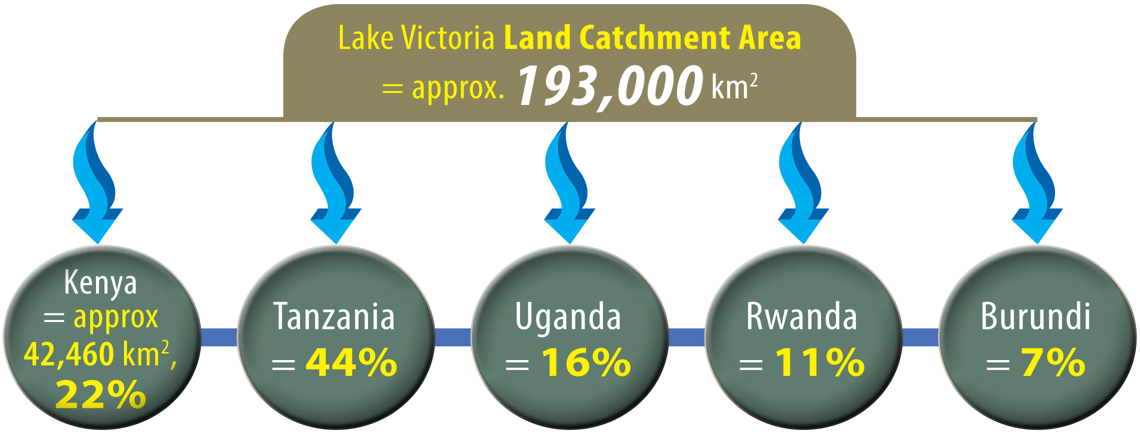
The Lake Magadi catchment extends from the highlands around Suswa in Narok County and moves in a southerly direction to drain into Lake Magadi approximately 81 km downstream. The Kisamis River flows in a southerly direction, where it is joined by several tributaries before draining into Lake Magadi. The river is characterized by steep slopes in the upper and middle zones, which give way to gentle rolling plains as the river flows downstream to the south.

3.1.2.11 **Lake Victoria**

Lake Victoria is the world's second and Africa's largest freshwater lake. It covers an area of 68,800 km^2, spanning 400 km north-south and 240 km east-west. Despite its massive area, the lake is relatively shallow, having only an average depth of 40 m, and a maximum depth of 79 m. The lake is shared by Kenya, Tanzania and Uganda. Only 6% of its surface area lies within the Kenyan territory, 51% and 43% lie in Tanzania and Uganda respectively. The northern shores of the lake touch the equator.

Lake Victoria has a wide land catchment area of about 193,000 km^2, which is almost three times the size of the lake. This catchment area extends over the three East African countries in addition to Rwanda and Burundi. The catchment area in Kenya covers approximately 42,460 km^2, while that in Tanzania, Uganda, Rwanda, and Burundi covers 44%, 16%, 11% and 7% respectively. This is the area from which rivers carry water, nutrients, sediments and pollutants into the lake. For this study, the team only concentrated on the catchment situated in Kenya.

The rivers which originate and enter the Lake from the Kenyan catchment contribute 38% of the total river discharge entering Lake Victoria from land catchment. However, River Mara, which enters the lake from Tanzania and contributes about 5% of the water draining into the lake, has most of its sources in the Kenyan catchment. Therefore, the total contribution of Kenyan catchment is estimated at about 42% of land catchment input. Consequently, activities in Kenyan catchments potentially affect a substantial portion of the river discharge into the lake and especially in Winam Gulf. The main rivers and their discharge percentages are: Nzoia, 39%; Gucha-Migori, 20%; Sondu, 14%; Yala, 13%; Nyando, 6%; and Sio, 4%. The remaining 4% comes from various streams including Awach Seme, Awach Kibos and Awach Kano (clustered as North Awach) and Awach Tende and Awach Kibuon (clustered as South Awach).



Historical records show that there were heavy floods in 1916–1918 and again in 1961–1964, although the floods in 1916–1918 were lighter in comparison, having mainly been limited to the area of Lake Victoria, southern Sudan and southwestern Ethiopia (Conway 2004). The heaviest floods ever experienced in the Blue Nile happened in 1878 when Lake Victoria rose by 0.91 meters by 0.91 meters. It is noteworthy that 1878 was also the year of a major ENSO event (Conway, 2004). Water balance studies on Lake Victoria have shown that the increase in water levels in 1961 was largely due to extremely high rainfall over the lake and its catchment in October and November 1961 and consistently wet conditions in the subsequent 3 years—1962, 1963 and 1964. Increased rainfall intensity after 1964 when compared to that before 1961 could explain the sustained increased in the level of water in the lake (Conway, 2004). Discussions with elders living near the lake indicate that the lake has been flooding about once in every 60 years. The recent increase in water levels has been a response to the high rainfall received between April 2019 and May 2020 (Figure 61).

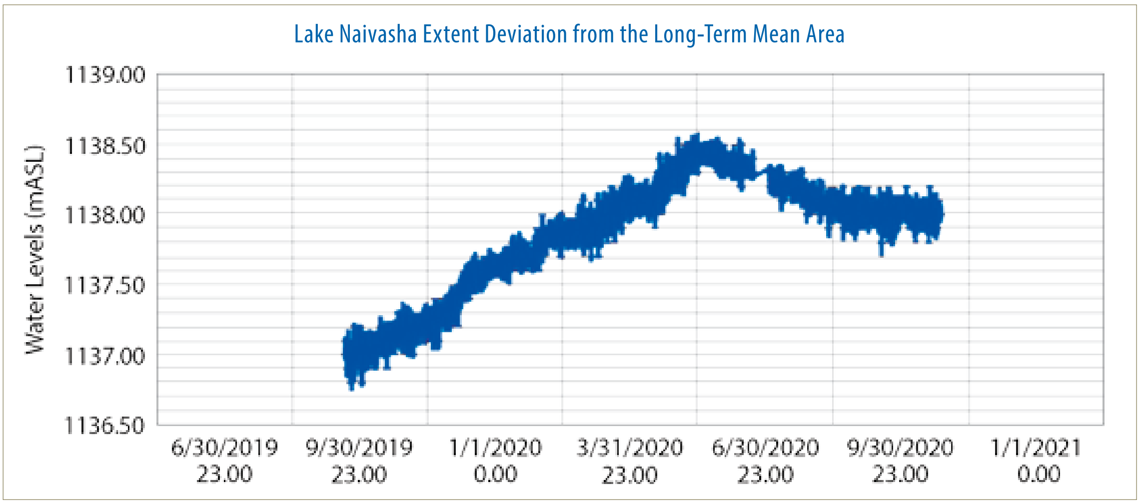


Figure 61: Lake Victoria water level from September 2019 to October 2020.

3.2 Anthropogenic Causes: Land Degradation

Forest ecosystems provide a continuous flow of essential goods and services that directly and indirectly support the Kenyan economy whose main pillars are agriculture and unique natural ecosystems. Closed forests are crucial water catchments and harbour a disproportionate amount of Kenya's biodiversity. The 5 largest blocks of forests are Mt. Kenya, the Aberdare Range, the Mau Complex, Mt. Elgon and the Cherangany Hills. These montane forests constitute the main "water towers" of Kenya and form the upper catchment of all main rivers in Kenya. Yet, the forest cover in these "water towers" has significantly reduced over the years as seen in the Landsat satellite images. This has contributed to the disruption of the hydrological cycle and to soil erosion that is one of the major causes of the happening in all the lakes. Some of the factors that have contributed to the changes in land use observed across the water basins include increased population, urbanization, intensified agricultural activities, and poor management of forests (lack of sound programmes on forest management, forest fires, and deforestation). These montane forests cause increased precipitation in the rainy seasons and ensure permanent flow of rivers during the dry seasons.

3.3 Geological and Tectonic Causes

Since 2010, the lakes within the Kenya Rift Valley have recorded a significant rise in their water levels, submerging land, homes and habitats. The current rising water levels in lakes in the Kenya Rift Valley is an isolated event—lakes in the Ethiopian Rift Valley have also risen in the same period. Generally, lakes in the rift valley have undergone significant geological and historical changes. Recent history shows a significant increase in lake water levels in 1901, 1963 and presently since 2013. In the Pleistocene, Lakes Nakuru-Elmenteita-Naivasha were one lake basin. The lake sediments associated with this expansive lake are seen in Ol Njorowa Gorge and Kariandusi Prehistoric site where diatomaceous earth is exposed. Lake Turkana basin to the northern end of Kenya Rift Valley covered a much wider basin whose lake-bed sediments can be traced to the Petrified Forest area and Koobi Fora Prehistoric site, both in Sibiloi National Park, Marsabit County. In the south, the Magadi-Natron was one basin with sediments seen as far north as at Olorgesailie Monument, a Prehistoric Museum site at the foot of Olorgesailie volcano.

The evolution of these lakes over time can be classified into:

i) Tectonic influence

The East African Rift System (EARS) displays a unique topographic province and tectonic belt that stretches for more than 5000 km from the Gulf of Aden to Mozambique. The rift system hosts several lake basins of varying sizes and morphology whose depositional environments are largely influenced by tectonic, volcanism and climate-driven processes (Bergner et al., 2009). Historically, these lake basins show evidence of temporal evolution, where the lakes within the rift flooded in Pleistocene times (45 million years ago), but perhaps not as high as what is being witnessed at present. These episodes have been attributed to extensional tectonics and the associated resurgent magmatic activities as well as to the changing climatic conditions that have profoundly shaped the present morphology of these lake basins. During extreme wet periods in the past, such as during the Early Holocene climate optimum, the levels of the lakes were high, and all basins evolved toward freshwater systems. For instance, the terraces observed above Lakes Nakuru, Naivasha and Elmenteita reveal strandlines of the Great Gamblian Lake that was once covered by water in the Early Holocene (about 30 million years ago). This was later affected by magmatic activities like Eburru massif that led to the segmentation of the lake into three sub-basins.

Since the EARs is an active tectonic belt characterized by extensional stress-regime, it is anticipated that a myriad of tectonic forces continues to shape the present rift geometry including the segmentation of rift lake basins. Such forces include magmatic stresses that have led to formation of major volcanic edifices, seismicity, and to some extent, the influence of anthropogenic activities. Similarly, the far-field tectono-magmatic field stress could also be of influence on the observed surging water levels in the lakes. The rift valley, being an active extension zone, the variance of extension rates with respect to far-tectonic process happening at Mid-Atlantic ridge could have far-reaching implications on the East African Rift system (EARs).

Remarkably, by virtue that these lakes are located within an active tectonic belt where open faults and fractures continue to dissipate significant amounts of magmatic gases like. CO_2, the likelihood of high CO_2 gas concentration within water bodies raises major concerns on safety implications. This is likely considering that some of the submerged geysers at Lake Bogoria could potentially lead to gas saturation, a phenomenon that is replicable across the other lakes in the rift valley due to the faulted nature of the basins.

ii) Tectonic control of drainage into the Rift Valley lakes

The general volcano-tectonic segmentation of the rift valley lake basins also influences drainage networks and catchment hydrology in addition to anthropogenic factors. The varied rift morphology, volcanism and fault patterns on the floor display complex geometries at catchment areas that control the runoff of surface water and the storage of groundwater. In fact, all the lakes in the rift are considered to have significant components of underground recharge and discharge. Examples are Lake Naivasha and Lake Baringo which have no known surface outflow channels, yet they remain relatively fresh in spite of high evapotranspiration. Similarly, Lake Magadi to the south and lake Bogoria to the north of the Kenya Dome receive substantial input of underground recharge from the deeply incised faults within the rift shoulders and axial flows from as far as Mt. Suswa for Lake Magadi. Notably, the groundwater is always connected to springs and lakes and is a major source of water stabilizing the lake water levels where there are no obvious surface inputs. An image of Lake Magadi area shows a terrain of a highly fractured volcano-tectonic environment with N-S running fault blocks and graben (Figure 62) that highly influence both groundwater flow and surface run-off away from the depression of the lake.

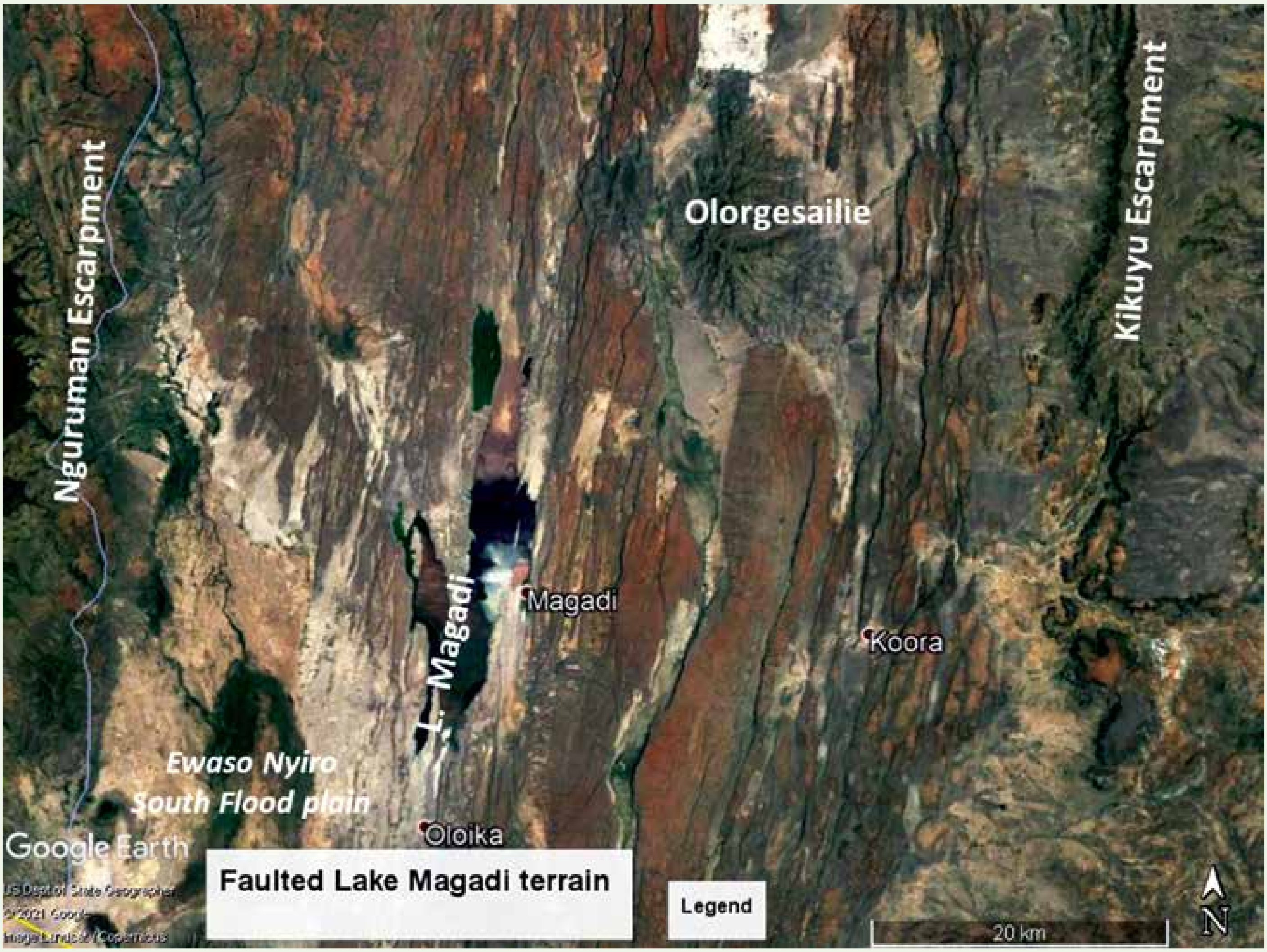


Figure 62: Google Earth image extract of Lake Magadi area in Kajiado County showing N-S trending normal fault structures that greatly control the drainage in the area.

iii) Saturation of groundwater

Groundwater saturation poses eminent threats to the discharge of lake water levels. There is a likelihood of subsurface groundwater exchange due to saturation resulting in an unbalanced negative moisture budget. The impacts of groundwater saturation within the fault-pathway networks are thought to limit underground out-flow from the body of the lake. The varied hydrodynamics within the rift lake basins due to increased precipitation are thought to be responsible for the current phenomenon. As such, the observed surge in lake water levels within EARs suggests that the lake basins could be experiencing periods of isostatic adjustments compounded with neotectonic deformation. This has the potential to create asymmetry of water bodies within the rift systems, creating escape routes for the waters and subsequent reduction of lake water levels.

4 Summary of Key Issues

4.1 Environment and Biodiversity

Table 13: Summary of Key Issues in Environment and Biodiversity

	Impacts on Environment and Biodiversity	Management Interventions Needed
(i)	Human-wildlife conflict: human lives lost due to crocodile attacks	Erecting a new protective boundary separating the wildlife from the humans
(ii)	Introduction of invasive aquatic plant species in the lake	Setting up monitoring and control points for invasive species
(iii)	Change of biodiversity structure	Undertaking a rapid ecological assessment to document and understand the changes
(iv)	Pollution of the lake from both point and non-point sources	Setting up water monitoring points around the rivers feeding the lake
(v)	Siltation and soil erosion	Establishing environment conservation strategies and soil erosion control mechanisms
(vi)	Loss of habitat for the herbivores, especially rhinos and buffaloes	Reclaiming and rehabilitating the lost habitat
(vii)	Loss of lake and river monitoring systems	Building more resilient monitoring stations which should be telemetry
(viii)	Change in the lake habitat (phytoplankton and zooplankton) resulting in flamingo migration	Reclaiming and rehabilitating the lost habitat
(ix)	Collapsed fence in parts of Lake Nakuru resulting in human/ wildlife conflict	Erecting a new fence
(x)	Reduced salinity of lake water	Setting up water monitoring points around the rivers feeding the lake

4.2 Socio-Economic Issues

Table 14: Summary of Key Issues Socio-Economic

Shelter and Resettlement		
Direct Impact	**Indirect Impact**	**Management Intervention Needed**
Destruction of and damage to shelter and housing	People sleep in wet, cold houses and floors in water marooned structures and shelters which will lead to acute respiratory infections and other diseases	(i) Distribution of shelter kits and basic shelter units as an immediate measure to reduce the exposure to adverse weather conditions

Direct Impact	Indirect Impact	Management Intervention Needed
Overcrowding due to displacement	Increased risk of transmission of communicable diseases such as measles and meningitis with similar conditions exacerbation to risks of COVID-19	(i) Relocation of the affected families to safer grounds not susceptible to the perennial flooding (ii) Undertaking resettlement and shelter reconstruction in safer grounds that will embrace the owner-driven approach and social capital support
Water, Sanitation and Hygiene		
Water Supply		
Standing water hampering access to existing water sources	Increased distance to functional water source	(i) Conducting detailed and comprehensive technical assessments for water infrastructure needs in the affected counties (ii) Distribution of safe water (water tracking) and means to store it to households at risk (iii) Construction and adoption of roof catchment technologies at the household level for conservation and storage of excess rain run-off (iv) Initiating rapid cleaning and disinfection programmes for affected water sources (v) Raising tube-wells and boreholes above flood water levels to prevent contamination (vi) Decontaminating water from community dams/pans/ponds or essential water bodies used for washing and cleaning utensils (vii) Distribution of household water treatment chemicals (viii) Repairing and improving existing water infrastructures (ix) Strengthening community capacity on water issues both in emergencies and programming: - Re-establish lake water level real-time monitoring stations with high rise platforms or floating equipment - Re-establishment of river monitoring stations with telemetry equipment to generate real-time data for establishment of Flood Early Warning Systems (FEWS) - Demarcate riparian reserve and educate communities on the proscribed activities to be undertaken within it - Distribution of safe water at affected landing sites
Disruption of water distribution systems due to: i) silting and clogging of pipes ii) Loss of intake points due to changes in the course of rivers iii) Damage to pumping equipment iv) Inundation of shallow (protected or unprotected) wells Contamination of drinking water sources by animal corpses, turbidity, organic or saline and leaking of polluted water and sewerage into the water supply system Destruction of Water Resource Monitoring infrastructure such as water level recorders and river gauging stations Loss of portable water at fish landing sites	Consumption of contaminated water hence potential risks of water-borne diseases. Insufficient quantity of water available per person per day Increased distance to functional water sources Early warning of the rising levels of lake water compromised Rates of river discharges into the lakes compromised thus affecting generation of warnings to communities Increased risk of outbreaks of water borne diseases due to use of contaminated lake water to clean fish	
Sanitation and Hygiene		
Overflowing of toilets and pit latrines	- Contamination of the environment - Lack of toilets and latrines leading to open defecation - Lack of available and functional toilets and latrines forcing women to wait until after dark to be able to use an (open air) latrines in private, which can cause constipation.	(i) Improving access to hygiene and sanitation services (ii) Provision of sanitary towels for women and girls of reproductive age (iii) Innovative approaches to sanitation in flooded areas, such as raised latrines, ecological sanitation, pit liners/rings, sealed pits or tanks, or contained leach fields (iv) Provision of adequate excreta disposal facilities and promotion of good excreta disposal practices

Direct Impact	Indirect Impact	Management Intervention Needed
Displacement leading to overcrowding	Existing latrines/toilets are filled quickly and rapidly overflow. Open defecation becomes a commonplace	(v) Repairs to existing sanitation and sewerage facilities. (vi) Construction of new sanitation units in areas with high population densities
High ground water table	Restricted excreta and waste disposal options	
	- Increased presence of vectors. - Accidental releases to groundwater. - Altered drainage patterns. Existing drainage channels, canals and pipes may be clogged with waste and/or mud.	
Loss of basic hygiene items for personal and domestic uses	Non-availability of safe drinking water and damage to sanitation infrastructure causing skin problems and infections.	
Health and Nutrition		
Interruption in basic health care services due to roads and power cuts disrupting the cold chain and flood waters damaging health facilities, equipment and medicine.	- Lack of access to basic healthcare - Overcrowded/straining health facilities - Poor nutritional status and associated illnesses Inaccessibility to reproductive health services especially for groups with less mobility such as widows, the elderly, and the disabled Risk of increased maternal and neonatal deaths. Socio-economic constraints to get access into reproductive health services. Poor access to sanitary goods for use	(i) Basic emergency rehabilitation and equipping of alternate health facilities to handle cases from health facilities in areas affected by floods (ii) Epidemiological surveillance and disease control (iii) Medical diagnosis and treatment through integrated outreaches including conducting clinical assessment on disability for PWDs and older persons, provision of assistive and mobility devices (iv) Support linkages and referrals for specialised services as well as follow ups; Community sensitization on Prevention, Protection and Response to SGBV (v) Public health and Vector control measures (vi) Need for educational programs designed for men and women in different age groups (vii) Need for an active monitoring system to follow the reproductive health status of all affected people in highly flooded regions (viii) Disseminate health and nutrition lifeline communication messages, for instance baby friendly community interventions to promote breast feeding, optimal complementary feeding and maternal nutrition through: a) Formation and training of Community Mother Support Group and mother to mother support groups and close links to health centres and local authorities b) Home visitations c) Community campaigns for Maternal Infant and Young Child Nutrition

Psychological trauma and Stress	Low/weak coping mechanism for special groups like PWDs and older persons. The affected households are currently depending on relatives, well-wishers and friends at their new settlements to obtain food. This lowers their esteem. Breastfeeding is compromised which may result in an increase in cases of under-nutrition in infants	d) Sustain referral networks e) Screening for malnutrition
Overcrowding due to displacement	Increased risk of transmission of communicable diseases such as measles, tuberculosis, and presently COVID-19 Inadequate childcare practices	
Disruption of water availability and consumption of unsafe drinking water	- Water-borne diseases like diarrhea, acute respiratory infections (ARI) and skin infections especially in children	
Disruption of household food security	- Poor dietary diversity. - Most of the caretakers might not be aware of the BMS Act, hence end up violated - Most women affected by floods undertake extreme workload like selling of firewood and doing casual works to survive or to lead their livelihood. This puts them at risk of sexual exploitation	
Destruction of and damage to shelters	- People sleep in cold shanties/tents which can lead to acute respiratory infections - Separation of family members, especially between children and parents which might affect parental care	

Increase in SGBV	- Increased perpetuation and imbalanced gender and power relations; gender violence; harmful customary and traditional practices including FGM, early marriages, forced abortion; and poor access to health services. - Lack of legal and legislative support for survivors of sexual violence and/or poor linkages and cross-referral mechanisms that hinder access to justice for survivors	
Increased numbers of those who default on medical appointments	A projected increase in the number of those who default on: immunization (children & pregnant women), nutrition, persons with other lifestyle conditions like person living with HIV/AIDs, TB, and Diabetes due to inaccessibility of health services caused by poor or destroyed infrastructure Poor mechanisms of tracing those who default on health appointments	
Limitation on transportation of drugs and nutrition supplements	Increase in mortality rates and malnutrition among children under five due to poor management of cases	
Food Security and Livelihoods		
Loss of food stock, crop yields and livestock	- Decreased availability of food due to loss of income. - Increase of prices for basic foods and commodities	(i) Supply of high breed seeds and fertilizers (ii) Market support, for instance through reinstatement of infrastructure (iii) Re-initiate support by providing capital (iv) Subsidizing land tilling and ploughing (v) Providing cash for work, food for work, and unconditional cash transfers (vi) Methods for drying and preserving seed stocks. (vii) Distribution of farm inputs and tools (viii) Offering extensions on credit (ix) Repairing roads and other infrastructure

Loss of farm tools, seeds and channels for land irrigation	- Worsening of the food security situation in the medium- and long-term. - Increase of prices of food and basic commodities	
Floods destroy standing crops	Worsening of the food security situation in the medium- and long-term	
Closure or downscaling of industries and business operations	- Loss of employment - Reduction in market productivities and supply chains competitiveness and marketability in the local, national and international markets e.g. Tata Chemicals	
- Destruction of fishing canoes by storms and loss of fishing nets - Loss of fish farms	Worsening food security	Providing cash for work, food for work, and unconditional cash transfers
Loss of fish handling facilities at landing sites leading to post harvest loses	Deficit in fish supply and high prices of fish in the markets	Rehabilitation of landing site infrastructure

4.3 Human-Wildlife Issues

The key issue in the tension between humans and wildlife is the loss of human lives due to attacks by and threats from wildlife. Three human lives were lost to attacks by hippos around Lake Ol' Bolossat. Further, there have been reports of threats to human lives around Lake Baringo as the hippos move closer to human following the rising levels of the lake which have left wildlife with reduced land available grazing and movement. Hippos and crocodiles have also been reported as being regularly seen in the Loboi area. Around Lake Naivasha, there have been reports of movement of wildlife into residential areas.

Some farmers with large tracts of land have been forced to undertake supplemental feeding of wildlife as they are now dying of starvation. Marula Estates limited has had to give hay to the large mammals living within their riparian land.

Kenya Wildlife Service has had to translocate wildlife facing the threat of starvation due to rising lake levels. This included the movement of Giraffe, impala, Ostrich and Warthog from Longcharo Island to the mainland within Ruko Conservancy, Lake Baringo, Baringo County. More wildlife has had to be moved from the riparian land along Lake Naivasha to Kedong Ranch, including 9 Masai Giraffe.

Lake Nakuru within the Lake Nakuru National Park (LNNP) has expanded well beyond the gazetted park boundaries. The park is fenced by an electric fence but due to the rising lake levels, the electric fence is not active as about 4 kms of it is submerged. This together with the recent records of fish in Lake Nakuru has led to a challenge of community members sneaking into the park to do illegal fishing which has resulted in two deaths.

4.4 Legal Issues

Several legal issues are bound to arise following the impacts of the rising lake water levels in the areas visited. In the aftermath of these floods and in the process of addressing some of the effects, the following legal issues are among those that might come up:

i) Compensation to legal owners of lands which have been submerged;

ii) The process to determine and map the new riparian borders, if and when undertaken, is expected to elicit legal concerns from affected persons;

iii) Compensation for loss of earning to those whose legal businesses have been destroyed by the floods;

iv) Petitions for resettlement to safer grounds of those affected by the flooding;

v) Compensation for loss of human lives, livestock, and destruction of crops as a result of the rampant human-wildlife conflict occasioned and exacerbated by the changing habitat along these lakes; and,

vi) Objections to and petitions against proposals to enforce regulations on encroachment into specified areas after developing and submitting a detailed map of proposed new boundaries along the shores of these lakes.

vii) Petitions on which methods to apply in delineating riparian lands as the high water-mark contour in the areas surrounding the lakes. Further work is being undertaken to have the new boundaries recognized by the National Land Commission of Kenya and to accord riparian and ecologically sensitive areas the protection they deserve from the relevant government agencies and more so by the local communities and adjacent landowners. It should be noted however that there is lack of data of the highest and lowest water marks ever recorded for various water bodies even though Article 62 of the Constitution provides that the land between the highest and the lowest water marks is public.

viii) Injunctions by business owners against payment of land rates and renewal of licenses for the businesses that have been affected by the floods.

Ecological Impacts:

Key ecological impacts include loss of habitat especially for wildlife. The rising lake waters has resulted in the starvation of large mammals due to lack of food. There have been reports of mass deaths of large mammals including Wildebeest, Impala, Waterbuck and Thompsons' Gazelles within the Crescent Island.

The huge increase in lake levels has resulted in changes in the water quality of the saline lakes. The rift valley lakes are mainly saline but are now exhibiting characteristics of freshwater lakes. Lake Nakuru has had a huge increase of birds recorded freshwater within freshwater systems. These include Comorants, African Darters, Great White Pelicans.

There has been an accidental introduction of fish (Nile Tilapia) within lake Nakuru. This is thought to have originated from the Njoro Sub Catchment of the Njoro river, a tributary of Lake Nakuru. The fish presence has caused various challenges including social challenges as currently there are people based at Mwariki and Barut ward who have embraced fishing as an income generating activity.

Part of the Nakuru old town sewage treatment plant is currently underwater. There is a challenge of solid and liquid waste flowing directly into the lake. This has resulted in high nutrient levels in the lake causing anoxic conditions. The anoxic conditions manifest as fish die-offs which were reported in February 2020.

5 Recommended Interventions Measures

The Multi Agency Team, based on their findings during the scoping mission, have recommended intervention measures to assist the affected communities, rebuild infrastructure, restore the lake ecosystem and mitigate challenges that may be posed by similar events in future. The recommendations are categorised into four based on urgency in terms of timelines as elaborated below:

5.1 Immediate Intervention Measures

Immediate intervention measures are urgent actions intended to cushion the affected people and wildlife from severe suffering as a result of the crisis of the rising water levels. These are actions that need to be taken within 3 months (0–3 months). The recommended immediate intervention measures in the report cover the following broad areas of action:

(i) **Provision of immediate humanitarian assistance:** The affected communities need to be provided with food and non-food items as well as incentives, subsidies and cash transfers to enable them to cope with the crisis. The non-food items and services include shelter and shelter kits, emergency health services, health and nutrition, potable water, hygiene and sanitation facilities and psycho-social support;

(ii) **Government-led public engagements with affected persons:** This is necessary to restore confidence and give hope as well as to provide an assurance of government commitment to support and walk with the affected households as a first step of getting the affected persons back to life. This should include addressing the issue of increasing human-wildlife conflicts;

(iii) **Creating awareness on climate change**: This can be done using simple illustrations that would lead to co-creation of solutions and therefore easy buy-in of proposed solutions using participatory scenario development approach. This should include addressing the issue of increasing human-wildlife conflicts;

(iv) **Closer monitoring of lake levels:** It is necessary to check the extent of swelling waters that may potentially shear-off from historical-boundaries. This will help avert hazards in the future;

(v) **Closer monitoring of meteorological patterns:** Simulation of future scenarios and establishment of a Flood Early Warning System to assist communities to move out of danger in case of possible swelling is needed; and,

(vi) **Rapid assessment of impacts of rising lake levels** on biodiversity and implications on food security in the affected areas is urgently needed.

In summary, the following areas are a priority (see budget and implementation matrix in Appendix 4):

1. Relief and cash assistance to affected communities
2. Emergency health and hygiene services;
3. Water, sanitation and irrigation;
4. Emergency shelter kits;
5. The education sector;
6. Agriculture and Food security;
7. The environment and Forestry sector;
8. The tourism and Wildlife sector;
9. The fisheries sector; and,
10. The energy sector.

5.2 Short-term Interventions

Short term intervention measures are actions geared towards supporting early recovery of the affected communities and enabling them to settle down and restart their livelihoods. The scoping mission recommends that these actions be taken within a time frame of four months to one year. The interventions in this category cover the following broad areas:

(i) **Restoring livelihoods:** There is need to rescue businesses by providing them with capital;

(ii) **Rehabilitating/relocating/restoring damaged infrastructure** such as water supplies, sewerage plants, health centres, electricity, roads, schools, fish handling facilities as well as police stations and police posts as per the specified requirements;

(iii) **Flood control and catchment-wide conservation practices** including construction of dykes, upstream dams and bridges to reduce the impact of flood water on livelihoods and properties in general. This is geared towards enhancing percolation of rainwater and improving recharge of shallow unconfined underground aquifers which are integral to minimizing risks and impacts of the flooding and rising water levels; and

(iv) **Carrying out a study on the hydrochemistry of the lakes,** particularly isotope studies and on monitoring the saturation of carbon dioxide to understand the dynamics of each lake and the associated hazards due to swelling. This can be expended through engaging WRA sub-regional offices and County Governments for speedy execution.

5.3 Medium-term Interventions:

(i) **Conduct studies** on land use, land cover, and water balance on all the lakes to trace sources of lake sedimentation, and to gain knowledge on how to best establish the highest water mark under the worst-case scenarios in the history of the lakes to help in clearly defining and demarcating the boundaries around the lakes;

(ii) **Creation of buffer zones:** The government should consider buying off the affected areas to create a buffer zone;

(iii) **Drilling and installing groundwater monitoring boreholes:** These will help to determine the likelihood of episodic recharge within the aquifers due to heavy rainfall against groundwater saturation potential. This is geared towards monitoring potential isotactic adjustments that may often be catastrophic; and,

(iv) **Carry out research on tectonic movements and magmatic stresses,** including seismic monitoring to detect active zones potentially in distress due to swelling lakes. This should be conducted together with bathymetric studies to determine the depth of lakes and sediment topography.

5.4 Long-term Interventions:

(i) **Finalize and implement the National Lake Basin Management Strategy** which is at the Ministry of Water & Irrigation. The purpose of the strategy is to provide an integrated framework for the sustainable management and use of Lake Basin resources through informing policies, strategies, plans, projects and programmes, as well as to guide coordinated actions. It embraces all institutions mandated to manage and conserve land, water and other resources within each lake basin; recognizes the role of the public and other stakeholders in the conservation and governance of lake basins; embraces appropriate and practical state-of-the-art technologies and innovations which advance conservation and sustainability of water resources; advocates for a strong data, knowledge and information system for evidence-based decision making at all levels; and explores opportunities for broad-based financial mobilization; and

(ii) **Development of County Spatial Plans:** Government should re-dedicate efforts to support all the 47 Counties to prepare climate resilient County Spatial Plans that will anticipate such challenges in a timely manner. The CSP's should clearly delineate the new proposed high-water marks and provide clear guidelines on land use that will avert the continued developments in areas considered as riparian areas, under the relevant laws.

6 Conclusions

The Government undertakes to follow up with the recommendations in this report. These are categorized as short-, medium- and long-term actions. The interest of the local communities and the biodiversity within these areas is quite prominent and will drive further interventions and plans by the government, at the county and national levels to avert the continued rise and the resultant impacts of this devastating situation.

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6.1 Financing

The Government should set aside a budget for resolving some of the challenges identified in this report. The other partners should also be mobilized to contribute towards sustainably managing this challenge. Partners like UNDP and USAID among others should support the efforts to coordinate measures to respond to this issue adequately and sustainably.

UNDP and the Government should move to secure broad-based ownership and support to a comprehensive programme that will seek to sustainably manage this situation.

6.2 Way Forward

Given the magnitude of this challenge, the government should partner with UNDP and other multilateral and bilateral partners to mobilize the resources required through a multi-donor programme that will seek to resolve the short-, medium- and long-term issues identified in this report. UNDP and the Government should move to secure broad-based ownership and support to a comprehensive programme that will seek to sustainably manage this situation.

Annexes

ANNEX 1: Implementation Matrix of Intervention Measures for the Rising Water Levels in the Rift Valley Lakes, Turkwel Gorge Dam and Lake Victoria

IMMEDIATE INTERVENTIONS
(Time Frame 0 to 3 Months)

No.	Activity	Unit of measure	Qty	Time Frame (Months)			Actor	Activity Cost (KSh)	
				1	2	3			
1	**Intervention Measure: Provision of Relief and Cash Assistance**								
1.1	Disbursement cash using appropriate cash transfer delivery mechanism (for 3 Months) – Baringo	HH / Month	3087				Ministry of Devolution/ Ministry of Interior	41,674,500	
1.2	Disbursement cash using appropriate cash transfer delivery mechanism (for 3 Months) – Nakuru	HH / Month	1700				Ministry of Devolution/ Ministry of Interior	22,950,000	
1.3	Disbursement cash using appropriate cash transfer delivery mechanism (for 3 Months) – Nyandarua	HH / Month	200				Ministry of Devolution/ Ministry of Interior	2,700,000	
1.4	Disbursement cash using appropriate cash transfer delivery mechanism (for 3 Months) – West Pokot	HH / Month	1500				Ministry of Devolution/ Ministry of Interior	20,250,000	
1.5	Disbursement cash using appropriate cash transfer delivery mechanism (for 3 Months) – Turkana	HH / Month	4053				Ministry of Devolution/ Ministry of Interior	54,715,500	
1.6	Disbursement cash using appropriate cash transfer delivery mechanism (for 3 Months) – Marsabit	HH / Month	3710				Ministry of Devolution/ Ministry of Interior	50,085,000	
1.7	Disbursement cash using appropriate cash transfer delivery mechanism (for 3 Months) – Kajiado	HH / Month	500				Ministry of Devolution/ Ministry of Interior	6,750,000	
1.8	Disbursement cash using appropriate cash transfer delivery mechanism (for 3 Months) – Busia	HH / Month	8922				Ministry of Devolution/ Ministry of Interior	120,447,000	
1.9	Disbursement cash using appropriate cash transfer delivery mechanism (for 3 Months) – Kisumu	HH / Month	13800				Ministry of Devolution/ Ministry of Interior	186,300,000	
1.1	Disbursement cash using appropriate cash transfer delivery mechanism (for 3 Months) – Siaya	HH / Month	32507				Ministry of Devolution/ Ministry of Interior	438,844,500	
1.11	Disbursement cash using appropriate cash transfer delivery mechanism (for 3 Months) – Homabay	HH / Month	7752				Ministry of Devolution/ Ministry of Interior	104,652,000	

No.	Activity	Unit of measure	Qty	Time Frame (Months)			Actor	Activity Cost (KSh)	
				1	2	3			
1.12	Disbursement cash using appropriate cash transfer delivery mechanism (for 3 Months) – Migori	HH / Month	3416				Ministry of Devolution/ Ministry of Interior	46,116,000	
	Total for Cash Disbursement							**1,095,484,500**	**1,095,484,500**
	Intervention: Other Cash Disbursements								
1.13	Transaction cost, Transfer and withdrawal charges – MPESA (Baringo, Nakuru, West Pokot, Turkana, Marsabit, Samburu, Kajiado, Busia, Siaya, Kisumu, Homabay, Migori)	Transfer					Ministry of Devolution/ Ministry of Interior	29,179,008	
1.14	Target and register beneficiaries – Community meetings at county level	Pax / County	300				Ministry of Devolution/ Ministry of Interior	180,000	
1.15	Cash working group meetings	Pax / County	150				Ministry of Devolution/ Ministry of Interior	600,000	
1.16	Local Volunteers (10 volunteers per county), community mobilization, beneficiaries registration, validation, complaints, PDM	Pax / County	500				Ministry of Devolution/ Ministry of Interior	900,000	
1.17	Encashment monitoring – supervision from GoK/implementing actors for 3 days	Lumpsum/ County	10				Ministry of Devolution/ Ministry of Interior	4,000,000	
	Total for Other Cash Disbursements							**34,859,008**	**34,859,008**
	Relief and Cash Assistance Total							**1,130,343,508**	
2	**Intervention Measure: Provision of Emergency Health and Hygiene Services**								
2.1	Replenishment of Inter-agency Emergency Health Kit, Basic Modules – (Baringo, Nakuru, West Pokot, Turkana, Marsabit, Samburu, Kajiado, Busia, Siaya, Kisumu, Homabay, Migori)	Kits	12				Ministry of Health/ Ministry of Interior/ County Govts	4,800,000	
2.2	Procurement of Rapid Diagnostic Kits, Malaria – (Baringo, Nakuru, West Pokot, Turkana, Marsabit, Samburu, Kajiado, Busia, Siaya, Kisumu, Homabay, Migori)	Kits	12				Ministry of Health/ Ministry of Interior/ County Govts	4,800,000	
2.3	Nutrition commodities (iron folic acid supplements) – (Baringo, West Pokot and Turkana, Marsabit)	Tins / county	3200				Ministry of Health/ Ministry of Interior/ County Govts	1,600,000	
2.4	Nutrition commodities (de-wormers) – (Baringo, Nakuru, Kajiado, West Pokot, Turkana, Busia, Kisumu, Siaya, Homabay, Migori)	Tins / County	8300				Ministry of Health/ Ministry of Interior/ County Govts	10,375,000	
2.5	Procurement NCD screening and monitoring equipment and Supplies	County	12				Ministry of Health/ Ministry of Interior/ County Govts	3,000,000	

No.	Activity	Unit of measure	Qty	Time Frame (Months)			Actor	Activity Cost (KSh)	
				1	2	3			
2.6	Procurement of assistive and mobility devices for PWDs – (Baringo, West Pokot, Turkana and Marsabit are considered to have higher numbers of PWDs whose concerns are not well addressed	County	4				Ministry of Health/ Ministry of Interior/ County Govts	2,400,000	
2.7	Sensitization of displaced population on disease prevention and control strategies	Sessions / County	54				Ministry of Health/ Ministry of Interior/ County Govts	1,749,600	
2.8	Conduct Individual and Group therapy sessions (Session costs which include 19 counsellors' costs)	Sessions / County	54				Ministry of Health/ Ministry of Interior/ County Govts	4,860,000	
2.9	Safe spaces for children and other groups for 19 counsellors (child therapy sessions)	County	9				Ministry of Health/ Ministry of Interior/ County Govts	810,000	
2.1	Identification of referral linkages for advanced care – (Baringo, West Pokot, Turkana, Busia, Marsabit)	County	5				Ministry of Health/ Ministry of Interior/ County Govts	3,000,000	
2.11	Facilitate the incorporation of 20 counsellors in all the outreaches (mainstreaming PSS at primary Health care level) – (Baringo, Nakuru, West Pokot, Turkana, Marsabit, Samburu, Kajiado, Busia, Siaya, Kisumu, Homabay, Migori)	Pax / County	45				Ministry of Health/ Ministry of Interior/ County Govts	5,791,500	
2.12	Conduct Rapid assessments in the affected counties for early identification and referral for appropriate management at health facilities – (Baringo, West Pokot, Turkana, Marsabit, Busia)	County	5				Ministry of Health/ Ministry of Interior/ County Govts	2,000,000	
2.13	Support coordination at County and Sub County level for review of available data and the situation and response gaps	County	13				Ministry of Health/ Ministry of Interior/ County Govts	975,000	
2.14	Facilitate referrals for Emergency Obstetric care – (Baringo, West Pokot, Turkana, Marsabit, Busia)	County	5				Ministry of Health/ Ministry of Interior/ County Govts	420,000	
2.15	Procurement of Reproductive Dignity kits (500 male and 500 female)	Kits / County	10000				Ministry of Health/ Ministry of Interior/ County Govts	15,000,000	
2.16	Community awareness on GBV prevention, response and reporting mechanisms	County	12				Ministry of Health/ Ministry of Interior/ County Govts	2,400,000	
2.17	Mapping, establishment and support of GBV referral pathway – (Baringo, West Pokot, Turkana and Marsabit)	County	4				Ministry of Health/ Ministry of Interior/ County Govts	400,000	
2.18	Support Health Emergencies county level coordination.	Meetings	13				Ministry of Health/ Ministry of Interior/ County Govts	1,950,000	

No.	Activity	Unit of measure	Qty	Time Frame (Months)			Actor	Activity Cost (KSh)	
				1	2	3			
2.19	Continuously monitor emergency health, Nutrition, MHPSS, RH and GBV intervention in the operation	County	13				Ministry of Health/ Ministry of Interior/ County Govts	7,800,000	
2.2	Include messages on preventing and responding to Sexual and Gender-Based Violence (SGBV) in all community outreach activities – (Baringo, West Pokot, Turkana and Marsabit have high cases reported)	County	4				Ministry of Health/ Ministry of Interior/ County Govts	960,000	
2.21	Map and make accessible information on local referral systems for any child protection concerns – (Baringo, West Pokot, Turkana and Marsabit)	County	4				Ministry of Health/ Ministry of Interior/ County Govts	960,000	
2.22	Provide essential services (including reception facilities, RFL, and access to education, health, shelter, and legal services) to unaccompanied and separated children and other children on their own – (Baringo, West Pokot, Turkana and Marsabit)	County	4				Ministry of Health/ Ministry of Interior/ County Govts	1,200,000	
2.23	Establish child-friendly spaces and community-based child protection activities, including educational ones – (Baringo, West Pokot, Turkana and Marsabit)	County	4				Ministry of Health/ Ministry of Interior/ County Govts	600,000	
2.24	Continuously monitor Inclusion and protection interventions in the operation – (Baringo, West Pokot, Turkana and Marsabit)	County	4				Ministry of Health/ Ministry of Interior / County Govts	600,000	
	Sub-Total							**78,451,100**	**78,451,100**
3	**Intervention Measure: Emergency Response**								
	Emergency referrals, social mobilization, risk communication and health promotion in view of the current surge of COVID-19	County					Ministry of Health/ Ministry of Interior/ County Govts	10,000,000	
	Integrated outreach services, expertise movement training and national technical support to counties (HEDRM,DSRU,EH)	County					Ministry of Health/ Ministry of Interior/ County Govts	50,000,000	
	Laboratory and diagnostic support	County					Ministry of Health/ Ministry of Interior/ County Govts	50,000,000	
	Pharmaceutical for emergency relief	County					Ministry of Health/ Ministry of Interior/ County Govts	100,000,000	
	Emergency Medical Commodities for field hospitals, trauma and mass casualty kits	County					Ministry of Health/ Ministry of Interior/ County Govts	20,000,000	
	Non-food items (Tents for field and mobile hospitals, forensic and blood service materials, GIS equipment)	County						50,000,000	

No.	Activity	Unit of measure	Qty	Time Frame (Months)			Actor	Activity Cost (KSh)	
				1	2	3			
	Sub-Total							**280,000,000**	**280,000,000**
3	**Intervention: Hygiene promotion**								
3.1	Procurement and distribution of WASH NFIs	Pieces	48678				Ministry of Health/ Ministry of Interior/ County Govts	3,650,850	
3.2	Water treatment chemicals (PUR) – 2 sachets/HH	Pieces	48678				Ministry of Health/ Ministry of Interior/ County Govts	1,168,272	
3.3	Water treatment chemicals (aqua tabs) – 2 tablets/HH	Pieces	48678				Ministry of Health/ Ministry of Interior/ County Govts	730,170	
3.4	Hygiene refresher training for community hygiene promoters (60 CHVs/Volunteers per county in 13 counties)	County	13				Ministry of Health/ Ministry of Interior/ County Govts	3,900,000	
3.5	Community clean up campaigns	County	13				Ministry of Health/ Ministry of Interior/ County Govts	3,900,000	
3.6	Community hygiene promoters' allowances	County / Pax	600				Ministry of Health/ Ministry of Interior/ County Govts	2,160,000	
	Sub-Total							**15,509,292**	**15,509,292**
4	**Intervention: Provision of Wash NFIs**								
4.1	Procurement and distribution of emergency latrine slabs for schools	Slabs	1168				Ministry of Health/ Ministry of Interior/ County Govts	7,009,632	
4.2	Jerricans (2 per family), to be distributed to vulnerable persons	Pieces	24339				Ministry of Health/ Ministry of Interior/ County Govts	6,084,750	
4.3	Bar Soap (2 per family, plus 1,000 bars to be distributed for hand washing	Pieces	25339				Ministry of Health/ Ministry of Interior/ County Govts	2,027,120	
4.4	Sanitary towels (1 pack per deserving beneficiary/females with menstrual cycles	Packs	14603				Ministry of Health/ Ministry of Interior/ County Govts	4,381,020	
	Sub-Total							**19,502,522**	**19,502,522**
5	**Intervention: Promotion of Appropriate Sanitation**								
	Education and awareness sessions on latrine construction	County / Pax	12				Ministry of Health/ Ministry of Interior/ County Govts	1,800,000	

No.	Activity	Unit of measure	Qty	Time Frame (Months)			Actor	Activity Cost (KSh)	
				1	2	3			
	Demonstration of latrine and hand washing facility construction	County	12				Ministry of Health/ Ministry of Interior/ County Govts	2,520,000	
	Rehabilitation of latrines in schools	County	12				Ministry of Health/ Ministry of Interior/ County Govts	60,000,000	
	Sub-Total							**64,320,000**	**64,320,000**
	Emergency Health and Hygiene Services Total							**177,782,914**	**457,782,914**
6	**Intervention: Supply of Clean and Safe Water**								
6.1	Rehabilitation and/or improvement of water points/systems (30 water points in 12 counties)	County / per system	12				Ministry of Water/ County Governments	79,200,000	
6.2	Disinfection of water points/wells	Well	12				Ministry of Water/ County Governments	720,000	
6.3	Deployment and operation of emergency water treatment plant including water trucking in counties with high displacement population density – (Baringo, West Pokot, Turkana, Busia, Kisumu, Homabay & Migori)	County / days	7				Ministry of Water/ County Governments	2,646,000	
6.4	Procurement of chemicals for the emergency treatment plant	County / Month	7				Ministry of Water/ County Governments	491,400	
6.5	Water quality testing	Unit	7				Ministry of Water/ County Governments	44,100	
6.6	Residual chlorine testing tablets	Tablet	7					25,200	
	Sub-Total							**83,126,700**	**83,126,700**
7	**Intervention: Water Level Monitoring**								
7.1	Rehabilitate and automate water level monitoring stations	Number	12				WRA	36,000,000	
7.2	Operationalize water quality monitoring system in all the lakes	WRA Sub Region	12				WRA	9,600,000	
7.3	Demarcation of highest water marks and riparian reserves	Lakes	12				WRA	120,000,000	
	Sub-Total							**165,600,000**	**165,600,000**
8	**Intervention: Support Irrigation**								
8.1	Supply of rice seedlings to affected farmlands for rural community resilience in West Kano, Budalangi, Ewaso Nyiro South and other lake Victoria basin	Kilograms	113200				Ministry of Water/ NIB	11,320,000	

No.	Activity	Unit of measure	Qty	Time Frame (Months)			Actor	Activity Cost (KSh)	
				1	2	3			
8.2	Supply of fertilizer to affected farmlands for rural community resilience in West Kano, Budalangi, Ewaso Nyiro South and other L Victoria basin	Bags	11320				Ministry of Water/ NIB	33,960,000	
8.3	Rotavation / land preparation of affected farmlands for rural community resilience in West Kano, Budalangi, Ewaso Nyiro South, and other in L Victoria basin	Acres	5640				Ministry of Water/ NIB	18,048,000	
	Sub-Total							**63,328,000**	**63,328,000**
	Water, Sanitation and Irrigation Total							**248,726,700**	
9	**Intervention: Provision of Emergency Shelter Kits**								
9.1	Procurement of Kitchen sets including branding	Pieces	24339				Ministry of Devolution	54,519,360	
9.2	Procurement of Tarpaulins including branding	Pieces	48678				Ministry of Devolution	55,492,920	
9.3	Procurement of Mosquito Nets	Pieces	48678				Ministry of Devolution	19,471,200	
9.4	Procurement of Sleeping Mats	Pieces	48678				Ministry of Devolution	12,169,500	
9.5	Storage for NFIs	County	12				Ministry of Devolution	600,000	
9.6	Transportation costs for NFIs and distribution	County	12				Ministry of Devolution	6,000,000	
	Emergency Shelter Total							**148,252,980**	**148,252,980**
10	**Intervention: Support Education**								
10.1	Procurement of temporary outdoor learning tents/construct temporary mabati structures for primary schools	County	60				Ministry of Education/ County Governments	30,000,000	
10.2	Procurement of temporary outdoor learning tents//construct temporary mabati structures for secondary schools	County	60				Ministry of Education/ County Governments	30,000,000	
10.3	Procure and distribution of facemasks for the vulnerable school going children	County	12				Ministry of Education/ County Governments	6,000,000	
	Education Total							**66,000,000**	**66,000,000**
11	**Intervention: Support Agriculture and Food Security (Irrigation)**								
11.1	Repair of pipelines and intake works	County	10				State Dept & concern County government	15,000,000	
11.2	Replacement/repair of damaged pumps	County	10				State Dept & concern County government	5,000,000	
11.3	Purchase and supply of recovery seeds – Maize	Tons	296				State Dept & concern County government	8,880,000	
11.4	Purchase and supply of recovery seeds – Beans	Tons	482				State Dept & concern County government	16,870,000	

No.	Activity	Unit of measure	Qty	Time Frame (Months)			Actor	Activity Cost (KSh)	
				1	2	3			
11.5	Purchase and supply of recovery seeds – Sorghum	Tons	113				State Dept & concern County government	3,390,000	
11.6	Purchase and supply of recovery seeds/ seedlings - Rice	Tons	436				State Dept & concern County government	15,260,000	
11.7	Purchase and supply of recovery seeds/ seedlings - Vegetables	Kgs	1374				State Dept & concern County government	2,748,000	
11.8	Purchase and supply of recovery seeds/ seedlings - Root crops	Kgs	6077				State Dept & concern County government	60,770,000	
11.9	Distribution (agric. Institutions and counties to provide trucks.	County	10				State Dept & concern county government	1,000,000	
11.1	Diagnosis, treatment and control of zoonotic diseases in animals	County	10				State Department of Livestock/ County Governments	30,000,000	
11.12	Animal feed distribution to flood affected herding communities	County	10				State Department of Livestock/ County Governments	15,000,000	
11.13	Pasture and fodder Development	County	10				State Department of Livestock/ County Governments	10,000,000	
	Agriculture/Food Security Total							**183,918,000**	**183,918,000**
12	**Intervention: Support Wildlife and Tourism**								
12.1	Undertake relocation of endangered wildlife in the flooding Protected areas including giraffes and zebras to safer locations - Lakes Baringo, Naivasha & LNNP	County	3				Ministry of Tourism and Wildlife	10,500,000	
12.2	Undertake Human Wildlife Conflict mitigation quick responses in Baringo, Busia, Homa Bay, Kisumu, Nakuru, Nyahururu, Migori	County	7				Ministry of Tourism and Wildlife	21,000,000	
12.3	Undertake the rehabilitation of the Electric Fence around Lake Nakuru National Park	KWS	1				Ministry of Tourism and Wildlife	16,000,000	
12.4	Undertake Roads Rehabilitation and upgrading in Lake Nakuru National Park	KWS LNNP	1				Ministry of Tourism and Wildlife	200,000,000	
12.5	Undertake the Rehabilitation of Tourism infrastructure in Lake Nakuru National Park (includes the airstrip at Naishi Campsites, Signages)	KWS LNNP	1				Ministry of Tourism and Wildlife	150,000,000	
12.6	Undertake construction of classrooms and laboratories for Aquatic Sciences KWSTI	KWS WRTI	14				Ministry of Tourism and Wildlife	21,000,000	
12.7	Support and establish temporary administration facilities and infrastructures in higher grounds for the submerged Lake Bogoria National Reserve to bolster continuation in operations and revenue collection	County	1				Ministry of Tourism and Wildlife	35,000,000	

No.	Activity	Unit of measure	Qty	Time Frame (Months)			Actor	Activity Cost (KSh)	
				1	2	3			
12.8	Undertake community sensitization foras, that will keep informing the communities living with wild animals, the importance of living with wildlife in harmony. Includes preparation and dissemination of Educational materials, engaging in Electronic and print media	County	3				Ministry of Tourism and Wildlife	6,000,000	
	Tourism and Wildlife Sector Total							**459,500,000**	**459,500,000**

13	Intervention: Support Fisheries								
13.1	Rehabilitation/reconstruction/relocation of fish landing sites affected by rising lake levels by provision of: (a) sanitary facilities–toilets, hand washing facilities, solid and liquid waste water areas. (b) preservation facilities–fish drying racks, fish smoking kilns, cool boxes, deep freezers. (c) fish handling facilities–hygienic temporary fish handling sheds, portable water (raised water tanks), temporary prefab offices (patrol units, BMUs, health certificates)- at 79 landing sites (Lakes Victoria–50; Naivasha–3; Turkana–19; Baringo 7) in Busia, Siaya, Kisumu, Homabay, Migori, Nakuru, Baringo, Turkana, Marsabit Counties.	Fish landing sites	79				SDFA&BE, Ministry of Interior, Kenya Fisheries Services (KeFS), County governments, Beach Management Units (BMUs), UNDP	395,000,000	
13.2	Rapid assessment of effect of flooding on cage culture (in Lake Victoria)	Surveys	1				SDFA&BE, Kenya Marine & Fisheries Research Institute (KMFRI), Counties, BMUs, UNDP	3,000,000	
13.3	Rapid assessment of effect of rising lake levels on capture fisheries or wild fish stocks on food security (Lakes Victoria, Naivasha, Baringo, Turkana and Turkwell Gorge dam)	Surveys	5				KMFRI, Counties, BMUs, UNDP	17,500,000	
13.4	Rapid assessment on the effect of rising water levels on distribution of obnoxious weed (water hyacinth) on Lakes Victoria, Naivasha, Baringo	Surveys	3				KMFRI, Counties, BMUs, UNDP	4,500,000	
13.5	Sensitization and Dissemination of information on flooding effect to fisher-folk communities (Busia, Siaya, Kisumu, Homabay, Migori, Nakuru, Baringo, Turkana, Marsabit, West Pokot)	Meetings/ County	10				SDFA&BE, Ministry of Interior, Counties, BMUs, UNDP	8,000,000	
	Fisheries Sector Total							**428,000,000**	**428,000,000**

No.	Activity	Unit of measure	Qty	Time Frame (Months)			Actor	Activity Cost (KSh)	
				1	2	3			
14	**Intervention: Provision of Energy**								
14.1	Re-routing submerged sections of 33kv lines at Lake Baringo						Ministry of Energy	5,146,908	
14.2	Re-routing submerged sections of 33kv lines at Kampi ya Samaki						Ministry of Energy	1,989,305	
14.3	Re-routing 132 kv double circuit at lake Nakuru						Ministry of Energy	189,863,787	
14.4	Re-route 11kv line South Ex Kihoto						Ministry of Energy	3,500,000	
14.5	Re-route 11kv line North Ex Marula						Ministry of Energy	20,000,000	
14.6	Re-site the North Ex DCK & South Ex DCK at lake Naivasha						Ministry of Energy	7,195,334	
	Energy Sector Total							**227,695,334**	**227,695,334**
	Grand Total for Immediate								**3,133,547,436**

SHORT TERM INTERVENTIONS
(Time Frame 4 to 12 Months)

No.	Activity	Unit of measure	Qty	Time Frame (Months)			Actor	Activity Cost (KSh)	
				4-Jun	7-Sep	10-Dec			
15	**Intervention: Support Agriculture**								
15.1	Sensitization of farmers on climate change	County (3 per county)	36				State dept & concerned county government	18,000,000	
15.2	Sensitization of farmers on climate smart agriculture	County	36				State dept & concerned county government	18,000,000	
15.3	Sensitize of farmers on agriculture land use planning	County	36				State dept & concerned county government	18,000,000	
	Sub-Total							**54,000,000**	**54,000,000**
16	**Intervention: Support Fisheries**								
16.1	Undertake frame surveys in Lakes Victoria, Turkana, Baringo, Naivasha, Solai and Turkwel gorge dam (inventory of; fish landing sites, facilities supporting fishing services at landing sites including accessibility, number of fishers, number and types of fishing boats and fishing gears, beach management units, alternative livelihoods etc) to guide development and management of the fisheries resources	Survey	6				SDFA&BE, KMFRI, KeFS, Counties, Universities, BMUs	35,000,000	

No.	Activity	Unit of measure	Qty	Time Frame (Months)			Actor	Activity Cost (KSh)	
				4-Jun	7-Sep	10-Dec			
16.2	Support fish farmers to acquire inputs for the rehabilitating severely destroyed ponds	No.	75				SDFA&BE, Counties	19.500,000	
16.3	Supporting fish farmers to acquire fingerings for stocking ponds	No.	755				SDFA&BE, Counties	7,285,500	
16.4	Restocking of public dams affected by floods	No.	55				SDFA&BE, Counties	30,800,000	
16.5	Sensitize fish farmers on adoption of climate smart and resilient technologies in aquaculture	Counties	11				SDFA&BE, Counties	11,000,000	
	Total for Short-Term Fisheries							**84,085,500**	**84,085,500**
17	**Intervention: Secure and Protect Riparian Lands**								
17.1	Undertake participatory surveys in Lakes Victoria, Turkana, Baringo, Naivasha, Solai and Turkwel gorge to establish Highest and Lowest Water Marks to prevent encroachment and guide development within these lands	Survey	6				NLC	35,000,000	
17.2	Undertake mapping and delineation of boundaries and pegging of riparian lands (land between highest and lowest water marks)	Mapping	6				NLC	35,000,000	
	Land Short-Term Sub-Total							**70,000,000**	**70,000,000**
18	**Intervention: inter-Community Conflicts**								
18.1	Conduct conflict risk assessment, surveillance and reporting	County	5				State Department for ASALs /State Department for Interior/County Governments	2,500,000	
18.2	Community sensitization and awareness on sharing of natural resources and importance of peaceful coexistenee	County	5				State Department for ASALs /State Department for Interior/County Governments	10,000,000	

No.	Activity	Unit of measure	Qty	Time Frame (Months)			Actor	Activity Cost (KSh)	
				4-Jun	7-Sep	10-Dec			
18.3	Establish and strengthen pe.ace committees in affected counties						State Department for ASALs /State Department for Interior/County Governments	4,500,000	
	Support coordination of interventions at county and sub-county level	Meetings	10				State Department for ASALs /State Department for Interior/County Governments	8,000,000	
	Devolution and ASAL Sub-Total							**25,000,000**	**25,000,000**
	Grand total Short-Term Measures							**233,085,500**	**233,085,500**

MEDIUM TERM INTERVENTIONS
(Time Frame 12 to 36 Months)

No.	Activity	Unit of measure	Qty	Time Frame (Months)			Actor	Activity Cost (KSh)	
				12	24	36			
19	**Intervention: Support Education**								
19.1	Improvement of infrastructure for the hosting schools and relocation of sorne schools to new sites	County	60				Ministry of Education/ County Govts	104,500,000	
19.2	Improvement of infrastructure for the hosting schools and relocation of sorne schools to new sites	County	60				Ministry of Education/ County Govts	104,500,000	
	Education Total							**209,000,000**	**209,000,000**
20	**Intervention: Support Agriculture**								
20.1	Sensitization of farmers on climate smart agriculture	County	36				State dept & concern county government	18,000,000	
20.2	Implementation of conservation agriculture (KSh 1,000 per h/h)	House holds	20,000 (25% of H/H)				"	20,000,000	
20.3	On farm water harvesting (3000m3 @KSh 300,000)	House holds	8,000 (10% of H/H).				State dept, county government & irrigation	2,400,000,000	
	Total Support Agriculture							**2,438,000,000**	**2,438,000,000**
21	**Intervention: Restoration and Conservation of Watersheds and Catchment Areas**								
21.1	Rehabilitation of key water catchment areas and construction of retention structures to reduce soil erosion	County	10				Ministry of Environment/ Ministry of Water / County Governments	1,000,000,000	

No.	Activity	Unit of measure	Qty	Time Frame (Months)			Actor	Activity Cost (KSh)	
				12	24	36			
21.1	Protection and conservation of river ecosystems	County	10				Ministry of Environment/ Ministry of Water/ County Governments	500,000,000	
21.3	Tree seed collection storage and distribution	Tones	50				Ministry of Environment	256,000,000	
21.4	Support to community nurseries						Ministry of Environment	500,000,000	
	Restoration and Conservation Total							**2,256,000,000**	**2,256,000,000**
22	**Intervention: Support Fisheries**								
22.1	Reconstruction of six modern Fish Landing sites facilities affected by the rising water levels of Lake Victoria. Rehabilitation of landing site facilities in Lake Baringo, Lake Naivasha	Modern Fish facilities	6				SDFA&BE, Ministry of Interior, KMFRI, KeFS, Counties, BMUs (NOTES The six landing sites at Lake Victoria will cost KSh 179m each as estimated by Public Works. This activity is captured in government budget)	1,114,000,000	
22.2	Fish stock assessments (catch assessments – fish species caught by fishermen and their value; fish biomass assessments – quantity of fish (tonnage) available in lakes and by species; fisheries socio-economics surveys – income and employment, trading, social aspects including gender dynamics, contribution to GDP etc) in Lakes Victoria, Turkana, Baringo, Naivasha, Solai and Turkwel gorge dam.	Surveys	8				SDFA&BE, KMFRI, KeFS, Universities, Counties, BMUs	165,000,000	
22.3	Monitoring fish critical habitats (fish breeding and nursery sites, fishing/cage culture grounds etc) for pollution in Lakes Victoria, Turkana, Baringo, Naivasha, Solai and Turkwel gorge dam.	Surveys	8				KMFRI, KeFS, Counties, BMUs	40,000,000	
	Total to Support Fisheries							**1,319,000,000**	**1,319,000,000**

No.	Activity	Unit of measure	Qty	Time Frame (Months)			Actor	Activity Cost (KSh)	
				12	24	36			
23	**Intervention: Drilling and installation of groundwater monitoring boreholes**								
	Drilling and installation of groundwater monitoring boreholes across the Rift lakes (L. Turkana 10Bhs, L. Baringo 2 Bhs, L. Bogoria 2Bhs, L. Solai 1Bh, L. OlBolosat 1Bh, L. Nakuru 3 Bhs, L. Naivasha 3Bhs, L. Elementaita 2Bhs, L. Magadi 2 Bhs) including Lake Victoria (7 Bhs) and Turkwel Gorge Dam (1 Bh) to determine episodic recharge against groundwater saturation and potential isostatic adjustments	Boreholes	34				Ministry of Mining, Mines and Geology, Kengen, UoN Geology	116,200,000	
	Total For Monitoring Well Drilling							**116,200,000**	**116,200,000**
24	**Intervention: Inventorize Affected Lands Abutting Lakes**								
24.1	Conduct an assessment to inventorize and establish databases for various parcels affected by flooding	County	6				NLC	60,000,000	
24.2	Develop and implement a resettlement action plan (RAP) for affected families/ households including exploring and facilitating appropriate compensation options	County	6				NLC	1,500,000,000	
24.3	Document lessons for sustainable land management in view of changing climatic conditions	County	6				NLC	300,000,000	
	Land Medium Term Total							**1,860,000,000**	**1,860,000,000**
25	**Intervention: inter-Community Conflicts**								
	Support to community resilience building initiatives (peace dividends community projects) to promote peaceful coexistence in affected areas	County	5				State Department for ASALs /State Department for Interior/County Governments	75,000,000	
	Devolution and ASAL Sub-total							**75,000,000**	**75,000,000**
	Grand Total for Medium-Term							**8,273,200,000**	**8,273,200,000**

LONG TERM INTERVENTIONS (Time Frame 48 to 72 Months)									
No.	**Activity**	**Unit of measure**	**Qty**	**Time Frame (Months)**			**Actor**	**Activity Cost (KSh)**	
				48	**60**	**72**			
24	**Intervention: Support Agriculture**								
24.1	Implementation of conservation agriculture (KSh 1,000 per h/h)	House holds	20,000 (25% of H/H)				State dept & concern county government	20,000,000	
24.2	On farm water harvesting (3000m3 @KSh 300,000)	House holds	15,000 (20% of H/H)				State dept, county government & irrigation	4,500,000,000	
24.3	Agriculture (Crop/livestock) diversification (KSh 1,000 per h/h)	House holds	23,000 (30% of H/H)				State dept, livestock,& county government	23,000,000	
	Sub-Total							**4,543,000,000**	**4,543,000,000**
25	**Intervention: Support Fisheries**								
25.1	Development of marine spatial plans for Lakes Victoria, Turkana, Baringo and Naivasha involving all relevant stakeholders	No of plans	4				SDFA&BE, Ministries of Interior, Mining, Transport, Tourism & Wildlife, Environment and Forestry, Culture, Water, Energy, Defence, Regional Development, NEMA, KMA, NMK, KWS, KMFRI, KFS, KFS, Counties	1,100,000,000	
	Total Support Fisheries							**1,100,000,000**	**1,100,000,000**
26	**Intervention: Research on Tectonic Movements and Magmatic Stresses**								
26.1	Undertake focused research on tectonic movements and magmatic stresses:- including seismic monitoring to detect active zones potentially in distress due to swelling lakes	Tectonic & seismic surveys	11				Ministry of Mining, Mines and Geology, Kengen, UoN Geology	275,000,000	
26.2	The tectonic survey should be conducted together with bathymetric studies to determine the depth to lake bed and sediment topography	Bathymetric surveys	11				Ministry of Mining, Mines and Geology, Kengen, UoN Geology	165,000,000	
	Total for Geology Survey							**440,000,000**	**440,000,000**

No.	Activity	Unit of measure	Qty	Time Frame (Months)			Actor	Activity Cost (KSh)	
				48	60	72			
27	**Intervention: Supply of Clean and Safe Water**								
27.1	Rehabilitation and improvement of water points systems	Water points in 10 Counties	30				Mînistry of Water, Sanitatîon and Irrigation / MDAs	66,000,000	
27.2	Disinfection of water points and wells						Mînistry of Water, Sanitatîon and Irrigation / MDAs	600,000	
27.3	Deployment and operation of emergency water treatment plants, (including water trucking in Baringo, West Pokot, Turkana, Busia, Kisumu, Homabay and Migori)						Mînistry of Water, Sanitatîon and Irrigation / MDAs	2,205,000	
27.4	Procurement of chemicals for the emergency treatment plant						Mînistry of Water, Sanitatîon and Irrigation / MDAs	409,500	
27.5	Water guality testing						Mînistry of Water, Sanitatîon and Irrigation / MDAs	36,750	
27.6	Residual chlorine testing						Mînistry of Water, Sanitatîon and Irrigation / MDAs	21,000	
	Total fo Supply of Clean and Safe Water							**69,272,250**	**69,272,250**
28	**Intervention: Water Level Monitoring**								
28.1	Rehabilitate and automate water level monitoring stations						Mînistry of Water, Sanitatîon and Irrigation / MDAs	30,000,000	
28.2	Operationalize water guality monitoring system in ail lakes						Mînistry of Water, Sanitatîon and Irrigation / MDAs	8,000,000	
28.3	Demarcation of highest water marks and riparian reserves						Mînistry of Water, Sanitatîon and Irrigation / MDAs	100,000,000	
	Total for Water Level Monitoring							**138,000,000**	**138,000,000**
29	**Intervention: Support Irrigation**								
29.1	Supply rice seedlings to affected farmlands for rural community resilience in West Kano, Budalangi.						Mînistry of Water, Sanitatîon and Irrigation / MDAs	5,660,000	

No.	Activity	Unit of measure	Qty	Time Frame (Months)			Actor	Activity Cost (KSh)	
				48	60	72			
29.2	Supply of fertilizer to affected farmlands for rural community resilience in West Kano, Budalangi, Ewaso Nyiro South and other Lake Victoria basin						Mînistry of Water, Sanitatîon and Irrigation / MDAs	16,980,000	
29.3	Rotavation / land preparation of affected farmlands for rural community resilience in West Kano, Budalangi, Ewaso Nyiro South, and other in Lake Victoria basin						Mînistry of Water, Sanitatîon and Irrigation / MDAs	9,056,000	
	Total for Supporting Irrigation							**31,696,000**	**31,696,000**
	Grand Total for Long-Term							**6,321,968,250**	**6,321,968,250**
	Short-Term+Medium-Term+Long-Term							**14,828,253,750**	**14,828,253,750**

SUMMARY OF INTERVENTION COSTS		
Category	**Cost KSh**	**Cost US$**
Immediate Intervention Measures	3,133,547,436	29,022,916
Short term Intervention Measures	233,085,500	2,158,799
Medium Term Intervention Measures	8,273,200,000	76,624,988
Long Term Intervention Measures	6,321,968,250	58,536,743
Grand Total	**17,961,180,119**	**166,353,433**

**Exchange rate is 107.97 per US$ as at 1/7/21.*

ANNEX 2: Terms of Reference and the Composition of the Scoping Mission to the Rift Valley Lakes, Turkwel Gorge Dam and Lake Victoria

ROLE OF CLIMATE CHANGE IN RISING WATER LEVELS AND OPTIONS FOR RESILIENCE BUILDING IN KENYA

SPECIAL TECHNICAL COMMITTEE

1. Background

The Ministry of Environment and Forestry and the County Government of Nakuru have requested UNDP to support a technical scoping study around the continued rise of Rift Valley lakes such as Lake Nakuru, Lake Bogoria, Lake Naivasha among others. Reports suggest that the waters of Lake Victoria are also rising. These rising water levels affect communities that live near the lakes and portend even greater danger to the communities residing downstream and along outlets of the lakes. This phenomenon and the challenge it is raising urgently need to be understood.

Various factors have been suggested as the possible causes of this phenomenon. The main one is climate change. The Eastern Africa region experiences extreme changes in climate. In the last two years, unusually high levels of precipitation were experienced in most areas including the catchments of the rift valley lakes. Lake water balance is normally affected by several factors, key among them being precipitation, water abstraction and land use. Recent geological changes across the active East Africa Rift Valley system could be one of the factors. The East African Rift System (EARS) is one the geologic wonders of the world, a place where the earth's tectonic forces are presently trying to create new plates by splitting apart old ones. Recent changes have suggested a lot more dynamic shifts within the tectonic plates, which could well be driving up the level of water in the lakes.

Since 2011, the Eastern Africa Rift Valley lakes in Kenya have registered significant increases in size. Increasing rainfall intensity recorded in the Kenya Highlands highly correlate with the rising levels of these lakes. Lakes Naivasha, Nakuru, Elmentaita and Bogoria sit on the sub-basin of the Aberdare Detachment System and so any study related to hydrological analysis needed for this sub-basin has to have more useful and realistic results. Of the four lakes, Lake Bogoria, Elmentaita and Nakuru are alkaline while Lake Naivasha is a freshwater lake. Previously, unpublished records of the levels of the Eastern African Rift Valley lakes in Kenya show significant rise and flooding of the mudflats and the ring of acacia forest around the lakes in 1901 and 1963. The current flooding suggests a return of a 50-year cyclic climatic event.

The proposed objectives of the study are:

(i) Assess the long-term climate variability and likely impacts on the areas experiencing rising water levels;

(ii) Assess the hydrology of the Rift Valley catchments including water balance in the lakes;

(iii) Map any geological incidences within the rift valley system that could be impacting on the lake basin;

(iv) Determine the changes in land and water use in the basins that may have (had) implications on water balance in the lakes and their associated risks;

(v) Produce inundation maps for each of the lakes over time, showing affected infrastructure, land use, man-made features, population and so on for risk mitigation purposes;

(vi Analyse patterns of livelihoods and settlement for each community depending on how much they rely on the lakes; and,

(vii) Recommend actions to reduce the risk associated with extreme changes in the size of lakes.

2. Justification for the Technical Working Group

UNDP has agreed to support the Government of Kenya to undertake a study on the rising water levels in the Rift Valley lakes and to design a comprehensive program that will support adaptation measures to this challenge. To ensure ownership and technical guidance from relevant Government Ministries, Departments, Agencies and Counties, a Special Technical Committee is to be formed to support this process. This Technical Committee will provide technical guidance on the implementation of this study, including facilitating acquisition of critical data and information to guide the delivery of the study. It will also validate the results from the study, while contributing to the comprehensive programme that will be unveiled to sustainably manage the challenge of rising water levels in Kenya's lakes.

The objectives of the Technical Working Group include:

(i) To provide guidance and support to the Project Focal Point at the Ministry of Environment and Forestry on technical processes, terms of references, evaluations, reports, data, and decision-making;

(ii) To facilitate seamless inter-ministerial coordination that is critical to the expeditious implementation of the study;

(iii) To provide technical advice on the final submissions that will be made to the Government of Kenya on the rising water levels in Kenya's lakes;

(iv) To regularly evaluate the implementation status of project activities, as well as ensure harmonization and rapid delivery;

(v) To process and generate consensus on key issues before they are presented to the Principal Secretaries for decision making; and

(vi) To support the design of the program on managing the challenge of rising waters.

3. Terms of Reference for the Technical Working Group

The Technical Committee will meet regularly to review the roadmap for undertaking this study in a timely manner. It will provide technical advice to UNDP, Ministry of Environment and Forestry, and other relevant parties. It will also identify risk and mitigation measures and review the process of the project.

Specifically, the Special Technical Committee will:

(i) Review and approve the Draft Terms of Reference, the proposed Roadmap of the Study and all other key documents that will guide successful execution of this activity;

(ii) Undertake a comprehensive scoping mission on all the lakes within the country affected by this challenge, and prepare a detailed report on the same for use by the Government of Kenya;

(iii) Approve the Terms of Reference for the Scoping Study on this problem;

(iv) Supervise the delivery of the scientific study on this area, as well as the proposed program to alleviate this challenge;

(v) Facilitate inter-ministerial collaboration and data acquisition and sharing for the successful implementation of the study; and,

(vi) Support efforts to mobilize resources that are coordinated by UNDP and the Ministry of Environment and Forestry for implementing the Program of Action that will be developed after the study.

4. Proposed Composition of Special Technical Committee

The Technical Working Group will comprise technical-level officers from the following institutions:

(i) Ministry of Environment and Forestry – Climate Change Directorate;

(ii) Ministry of Water and Sanitation;

(iii) The National Treasury;

(iv) Ministry of Energy – Geothermal Development Company, KenGen;

(v) Ministry of Devolution and Semi-Arid Lands;

(vi) Ministry of Interior and Coordination of National Government;

(vii) Council of Governors;

(viii) Select County Government Representatives – Water and Environment;

(ix) Department of Remote Sensing (DRSRS);

(x) National Environment Management Authority (NEMA);

(xi) Kenya Water Towers Agency (KWTA);

(xii) Academia (2);

(xiii) Private sector (2); and,

(xiv) Civil Society (2 representatives of women, youth and other organizations.

ANNEX 3: List of Technical Team Members who Participated in the Scoping Exercise

Regions	SN	Participants	Telephone	Emails
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Victoria, Sori	1.	**Nancy Murega – *Team Leader***	0722655864	murega2013@gmail.com

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ANNEX 4: The Questionnaire

1. Objectives of the investigation:

(i) Establish why the water levels of Rift Valley Lakes as well as Lake Victoria have been on the rise;

(ii) Conduct investigation and assessment, and consult, interview and collaborate with relevant institutions, agencies, and experts on these phenomena;

(iii) Give recommendations on the management and mitigation strategies concerning the rising lake levels;

(iv) Inform and advise the Cabinet Secretary on formulation of policy on national water resource management, water storage and flood control strategies;

(v) Liaise with other regional, national and international bodies for the better regulation of the management and use of water resources by paying attention to the following areas:

a) Sustainability of the hydrology of the Drainage Basin as an ecosystem;

b) Land use and settlement trends and their vulnerability to environmental and hydrological dynamics;

c) Community vulnerability to environmental dynamics and impacts from contaminated surface water and groundwater;

d) Land degradation; and

e) Fluorosis, soils and water transmitted ailments.

2. Introduction

This questionnaire is part of an appointed task force to assess the causes and the impacts of the rising lake waters in Kenya.

The first activity is the assessment of already-available global-scale information and data from major international sources, while the second activity is the assessment of questionnaire-based information and data. These two activities will later be combined for a more detailed assessment.

As part of the second category of activities, this questionnaire is designed to obtain your judgment on and perceptions of your "on-the-ground" experiences and observations regarding rising water levels in lakes and their basins in Kenya. It includes questions regarding (1) the "stresses" affecting lakes and their basins, such as increasing population and industrialization, increased erosion, and overfishing; (2) the "impairments" to the lake resulting from these stresses, such as degraded fish habitats and decreased water supply; and (3) the "impacts" or damages resulting from these impairments, such as degraded water quality, increased disease, and lost economic livelihoods. Your participation is critical to the successful completion of this important component of this study, and your efforts to assist us are appreciated.

The lake/reservoir basins on which your opinions are being sought in this questionnaire are located among different river basins east of the Lake Victoria region. The landscape is largely dominated by agricultural lands and grasslands. The overall population density is relatively high. Some part of this region exhibits very severe water stress.

QUESTION SET 1: Learning About You and Your Lake/Reservoir

1. What is the name of your lake/reservoir?

Nakuru, Solai, Elmenteita	Magadi, Ewaso Ngiro South Flood plain	Victoria	Naivasha, Ol' Bolossat	Baringo, Bogoria	Turkana, Turkwel Dam, Logipi

2. How well do you know the fish, animals, vegetation, and people around your lake?

Very well O Reasonably well O Not very well O

Is your knowledge based on your own experience or was it gained in some other way, such as through traditional or indigenous knowledge?

3. How close to the lake do you live? (State distance in miles or km from the shoreline)

4. How long have you lived at this location?

5. What do you normally use the lake for, and how often?

6. Do you derive any economic benefits from it (like fishing) or aesthetic well-being (scenic views or religious activities)? Please explain your answers.

QUESTION SET 2: The Magnitude or Intensity of the "Resource Provisioning Services" (Benefits) Generated in the Upstream River Basin Draining into Your Lake

Using your knowledge of your lake and the upstream river basin that drains into your lake, please indicate which one of these categories (little/not much; moderate/ so-so much; or an in-between condition) best reflects your opinion of your lake's "Resource Provisioning Services." This question relates not only to the situation upstream of the lake, but also to that in the river basin downstream of the lake.

1: Little/not much	2	3: Moderate/so-so	4	5: Much

A	Crop production in the upstream and downstream river basins	1	2	3	4	5
	Any comments					
B	Livestock production in the upstream and downstream river basins	1	2	3	4	5

C	Hydropower generation by impounding (damming) the upstream rivers flowing into the lake and/or by impounding the water flowing out of the lake into downstream river(s)	1	2	3	4	5
	Any comments					
D	Use of water for domestic purposes (drinking; cooking; laundry) in the upstream and downstream river basins	1	2	3	4	5
	Any comments					
E	Industrial water use in the upstream and downstream river basins	1	2	3	4	5
	Any comments					
F	Other water uses in the upstream and downstream river basins that generate benefits (please explain)	1	2	3	4	5
	Any comments					

QUESTION SET 3: Status of the Resource Provisioning Services (Benefits) Generated in and around the lake

Please indicate **which of** these categories (little/not much: moderate/so-so: much and or an in between condition) best reflects your opinion regarding the Resource Provisioning Services provided by your lake.

1: Little/not much	2	3: Moderate/so-so	4	5: Much

The Amount of Stress Placed on Your Lake by Resource Provision Activities						
A	Changes in lake water levels caused by upstream river water withdrawals for crop production, industrial, household and other uses and/or hydropower generation	1	2	3	4	5
	Please explain					
B	Changes in lake water levels caused by downstream river water withdrawals for crop production, industrial, household and other uses, as well as hydropower generation	1	2	3	4	5
	Please explain					
C	Lake water pollution due to urban, industrial and household wastewater discharges, as well as waste and sediment runoff from livestock production, flowing into upstream rivers	1	2	3	4	5
	Please explain					
D	Lake water level declines and fluctuations and/or lake water pollution caused by other upstream or downstream water uses	1	2	3	4	5
	Please explain					

QUESTION SET 4: The Magnitude or Intensity of the "Stress" Put on Your Lake by the Upstream or Downstream Activities Identified in QUESTION SET2

Considering your answers in QUESTION SET 2 above, please indicate **which one** of these categories (little/not much; moderate/so-so; much; or an in-between condition) best reflects your opinion of the "Stress" put on your lake by those activities, such as pollutants discharged into lake, sediment washed down into lake, water level fluctuations, excessive water withdrawals, etc.

1: Little/not much	2	3: Moderate/so-so	4	5: Much

Status of Resource Provisioning Services of Your Lake						
A	Crop production around the lake, using near- or in-lake water for irrigation	1	2	3	4	5
	Any comments					
B	Livestock production around the lake, using near- or in-lake water for raising livestock	1	2	3	4	5
	Any comments					
C	Lakeshore/near-shore industries using near- or in-lake water as water sources	1	2	3	4	5
	Any comments					
D	Cargo and passenger boat transportation for the surrounding lake population	1	2	3	4	5
	Any comments					
E	Hydropower generation using the impounded (dammed)lake water at the mouth of outflowing rivers from the lake	1	2	3	4	5
	Any comments					
F	Domestic water use (drinking; cooking; laundry) of lake water or immediately inflowing or outflow river water	1	2	3	4	5
	Any comments					

QUESTION SET 5: Status of the "Resource Provisioning Services" (Benefits) Generated in and around Your Lake (Continued).

1: Little/not much	2	3: Moderate/so-so	4	5: Much

Status of Resource Provision Services of Your Lake						
G	Bathing and other water contact activities by the community surrounding the lake	1	2	3	4	5
	Any comments					

H	Commercial large-scale fisheries	1	2	3	4	5
	Any comments					
I	Local subsistence fishing (cage culture; open water fisheries)	1	2	3	4	5
	Any comments Mostly open water fisheries					
J	Local tourism activities in and around the lakeshore region (recreation; bird watching; sports fishing; etc.)	1	2	3	4	5
	Any comments					
K	Other uses of the lake (please explain)	1	2	3	4	5
	Any comments Oil exploration					

QUESTION SET 5: The Degree or Intensity of the "Stress" Put on the Lake by the Activities in and around Your Lake as Identified in QUESTION SET 4

Please indicate **which one** of these categories (little/not much; moderate/so-so; much; or an in-between condition) best reflects your opinion regarding the "Stress" on your lake from the "Resource Provisioning Services" identified in QUESTION SET 4 above.

1: Little/not much	2	3: Moderate/so-so	4	5: Much

Degree of Stress from Resource Provisioning Services of Your Lake						
A	Stress from crop production around the lake, using near- or in-lake water for irrigation	1	2	3	4	5
	Any comments					
B	Stress from livestock production around the lake, using near- or in-lake water for raising livestock	1	2	3	4	5
	Any comments					
C	Stress from lakeshore/near-shore industries using near- or in-lake water as water sources	1	2	3	4	5
	Any comments					
D	Stress from cargo and passenger boat transportation for the surrounding lake population	1	2	3	4	5
	Any comments					
E	Stress from hydropower generation using the impounded (dammed) lake water at the mouth of outflowing rivers from the lake	1	2	3	4	5
	Any comments					

F	Stress from domestic water use (drinking; cooking; laundry) of lake water or immediately inflowing or outflow river water	1	2	3	4	5
	Any comments					
Degree of Stress from Resource Provisioning Services of Your Lake						
G	Bathing and other water contact activities by the surrounding lake community population	1	2	3	4	5
	Any comments					
H	Commercial large-scale fisheries	1	2	3	4	5
	Any comments					
I	Local subsistence fishing (cage culture; open water fisheries)	1	2	3	4	5
	Any comments					
J	Local tourism activities in and around the lakeshore region (recreation; bird watching; sports fishing; etc.)	1	2	3	4	5
	Any comments					
K	Other lake uses (please explain)	1	2	3	4	5
	Any comments Oil exploration					

QUESTION SET 6: The Status of "Cultural Services" in and around Your Lake

Please indicate **which one** of these categories (little/not much; moderate/so-so; much; or an in-between condition) best reflects your opinion of the "Cultural Services" provided by your lake.

1: Little/not much	2	3: Moderate/so-so	4	5: Much

Status of Cultural Services of Your Lake						
A	Aesthetic, human well-being and scenic values (like sailing, swimming, walkways for strolls, etc)	1	2	3	4	5
	Any comments					
B	Religious and spiritual values (festivals or religious traditions that centre around the lake)	1	2	3	4	5
	Any comments					

C	Historical significance (mentioned in scriptures, holy books, myths or legends regarding the lake)	1	2	3	4	5
	Any comments					
D	Educational value (students and researchers visit and research the lake and its plants and animals)	1	2	3	4	5
	Any comments					
E	Natural heritage (e.g., national parks; nature preserves) declared by the government and/or home to endangered species	1	2	3	4	5
	Any comments					

QUESTION SET 7: Status and Trends of Impairment of "Regulating Services" (Ecosystem Functions) of Your Lake Over Past Decades.

Which one of these categories (little/not much; moderate/so-so; much; or an in-between condition) best reflects your opinion of the Impairment of "Regulating Services" (ecosystem functions) of your lake? If you think there has been little or no Impairment of "Regulating Services" over the past decades, please indicate why you think so.

1: Little/not much	2	3: Moderate/so-so	4	5: Much

Changes in Ecosystem Functions of Your Lake						
A	Resultant increase in frequency of floods	1	2	3	4	5
	Please explain any increase					
B	Resultant increase in frequency of droughts	1	2	3	4	5
	Please explain any increase					
C	Negative changes in climate around lake	1	2	3	4	5
	Please explain any change					
D	Resultant decrease in pollution absorption capacity because of loss of wetlands or other natural habitats	1	2	3	4	5
	Please explain any decrease					
E	Resultant decrease in plant and animal habitats in and around the lake	1	2	3	4	5
	Please explain any decrease					
F	Resultant degradation of food chain established over time by native plant and animal species	1	2	3	4	5
	Please explain any degradation					

QUESTION SET 8: The Status and Trends of Impacts (Economic Damage, Public Health Hazard, Loss of Environmental Values/Benefits, etc.) of Your Lake Over Past Decades

Which one of these categories (little/not much; moderate/so-so; much; or an in-between condition) best reflects your opinion regarding how the Impairments identified in QUESTION SET 7 Impact the Ecosystem Functions of your lake? If you think there has been little or no Impact of your lake over past decades, please indicate why you think so.

1: Little/not much	2	3: Moderate/so-so	4	5: Much

Status and Trends of Impacts of Your Lake						
A	Economic impacts on crop production, livestock production and other agricultural activities near and around the lake using the lake water	1	2	3	4	5
	Any comments					
B	Economic impacts on industrial activities near and around the lake using the lake water	1	2	3	4	5
	Any comments					
C	Economic impacts on the commercial large-scale fisheries	1	2	3	4	5
	Any comments					
D	Economic impacts on cargo and passenger transportation for the surrounding communities	1	2	3	4	5
	Any comments					
E	Economic impacts on hydropower generation using the impounded lake water at the mouth of outflowing rivers	1	2	3	4	5
	Any comments					
F	Economic impacts on the local subsistence fisheries (cage culture, open water fisheries)	1	2	3	4	5
	Any comments					
G	Economic impacts on commercial tourism in and around the lakeshore region (recreation, bird watching etc.)	1	2	3	4	5
	Any comments					
H	Health impacts on the riparian (near-lake) population in relation to change in quality and quantity of lake water for domestic uses (drinking; cooking; laundry) and water contact activities (bathing, lakeshore fishing, etc.)	1	2	3	4	5
	Any comments					

I	Aesthetic, human well-being and scenic values (sailing, swimming, hiking, etc.), religious/spiritual values (festivals/religious traditions centering around the lake), historical significance (mentioned in scriptures, holy books, myths or lake legends), educational value (students/researchers visit and study the lake and its plants and animals, etc.), natural heritage (national parks, nature preserves, etc.) declared by the government	1	2	3	4	5
	Any comments					
J	Other lake uses (please identify)	1	2	3	4	5
	Any comments					

QUESTION SET 9: Policies and Monitoring Activities Regarding Your Lake.

1. Are there are formal or informal policies or legislation (laws, ordinances, rules, regulations) in place for managing your lake?

Yes O No O I Don't know O

Please also indicate to the best of your ability any existing laws/legislation for managing your lake, and any agencies/organizations that deal with these laws and legislation.

Name of Policy/Legislation/Rule/Custom			Responsible Agency/Organization
Formal	International		
	National		
	Local		
Informal	Social norms or traditional/ customary laws		

2. Is any formal/informal data or monitoring information available for your lake and/or watershed?

Yes O No O I Don't know O

If the answer is yes, can you indicate what is being measured for your lake (for example, water quality, numbers/types of fish, water flows/withdrawals, rainfall, etc.) and how often they are measured? If possible, please indicate if this information is available in electronic form (and name of website) or written form (and titles / sources of the publication)?

Name of Program/Activity			Responsible Agency/Organization
Formal	International		
	National		

	Local		
Informal	Individual and/ or community efforts		

QUESTION SET 10: Possible Improvements Regarding Your Lakes.

If you could make some changes to improve the health of your lake (such as clean-up activities, implementing pollution controls, increasing education/awareness, promoting nature tourism, sustainable fishing activities, bird watching, etc.), what would they be, and how do you think it would help the lake over the next few decades?

It would help a little O It would help a lot O I don't have any suggestions O

QUESTION SET 11: Additional Important Insights, Comments or Suggestions Regarding Your Lake.

Do you have any additional insights, concerns or suggestions that you think are important and should be included in assessing your lake?

CONTACT INFORMATION

Name	Last Name		First Name	

Age Range	18–30 O	31–40 O	41–50 O	51–60 O	61–70 O	70+ O
Gender	Male			Female		

Mailing address (including country)	
Telephone Number	
Email Address	
Occupation or profession	

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