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Rising Water Levels And The Loss And Damage On Shoreline Communities At Lake Turkana In Marsabit County

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Abstract
This report/research presents the impacts of rising Lake Turkana water levels on the shoreline communities of Loiyangalani, Moite, and Illeret in Marsabit County. The assessment reveals a severe and escalating humanitarian, ecological, and livelihood crisis driven by the combined effects of climate-induced rainfall variability in the Omo River catchment and upstream dam operations in Ethiopia. Since 2010, and more sharply after 2019, the lake has risen rapidly in a non-linear pattern, inundating thousands of hectares of land, displacing settlements, and undermining the socio-economic foundations of lake-shore communities.
The methodology employed a mixed-methods approach, integrating geospatial analysis of satellite imagery (2017–2025) with community-based participatory tools, including focus group discussions, key informant interviews, direct field observations, and structured engagement with ten Beach Management Units (BMUs) comprising 2,504 members. This approach ensured that scientific evidence was triangulated with lived community experiences.
Key findings indicate that:
1. *Lake Turkana has risen by approximately 150 meters years, that is 1.2Km from 2027 to 2025 expanding its surface area and volume, placing over 2,500 BMU members and their dependents at direct risk. Entire settlements, including much of the El Molo community, have been displaced. Health facilities, freshwater sources, schools, and roads have been severely damaged or rendered unusable.*
2. *Fishing and agro-pastoral livelihood systems are under acute threat. Twelve major fish landing beaches are submerged, and BMUs report **o**ver 50% declines in daily fish catches, triggering widespread economic contraction. Loss of dry season grazing land has significantly increased livestock vulnerability.*
3. *Women, youth, and marginalised groups face disproportionate impacts. Women constitute only 34% of BMU membership, limiting their influence over fisheries governance and access to recovery resources, while youth face escalating unemployment and psychosocial stress.*
4. *The risk assessment identified three extreme risks, that is, collapse of agropastoral systems, a public health crisis linked to contaminated water, and irreversible loss of El Molo cultural heritage—and five high-priority risks, including education system collapse and escalating resource-based conflict.*

Based on these findings, the report recommends a phased, spatially informed, and socially inclusive resilience strategy. Immediate actions include gazettement of hazard zones, implementation of a managed resettlement plan, establishment of community-based lake monitoring systems, and prioritisation of vulnerable groups in relief efforts. Medium-term measures focus on climate-resilient fisheries infrastructure, livelihood diversification, solar-powered fish processing for women's groups, and gender-balanced BMU governance. Long-term actions include scaling up successful livelihood models, formal protection of fish breeding zones, and strengthening community savings groups into formal SACCOs.
In conclusion, the rising waters of Lake Turkana represent an existential threat to the social, economic, and ecological fabric of Marsabit County's lakeshore communities. Urgent, coordinated, and sustained action by County and National Governments, together with development partners, is required to mitigate extreme risks, protect vulnerable populations, and secure a viable future for communities around Lake Turkana.
Key Words: *Loss and Damage, Climate Change, Raising Water Lakes.*

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I. Introduction And Background

Kenya's Rift Valley Lake system has been growing in an unexpected and steady way over the past few decades. Baringo, Naivasha, and Turkana are just a few of the lakes that have seen large increases in surface area and shoreline flooding. This makes it one of the most common climate-related risks in the country. Studies have primarily linked the phenomenon to heightened rainfall and modified fundamental hydrology, exacerbated by land use changes and catchment degradation (Dondeyne et al., 2024; Ayalew et al., 2023).

Lake Turkana, which is in northern Kenya, is the world's largest permanent desert lake and a UNESCO World Heritage Site. It is a good example of these dynamics. For a long time, its waters have supported the unique ways of life and cultures of communities like Dasanach, El Molo, Rendillle, Samburu and Turkana,. But now, this lifeline is in great danger because of the combined effects of climate change and human actions. It has gone from being a source of food to a source of deep crisis.

The crisis at Lake Turkana is a clear example of how the environment is changing on a global and regional scale. The climate in the Horn of Africa is becoming more unstable, with more frequent and severe droughts followed by periods of heavy rain (IPCC, 2022). Researchers have linked these changes in the weather in the Omo River's catchment basin, which comes from the Ethiopian highlands and makes up more than 90% of the lake's inflow, to the lake's unstable water levels (Gownarise et al., 2017). Dondeyne et al. (2024) have observed that the lake level is highly responsive to variations in rainfall within the Omo Basin, resulting in substantial fluctuations capable of inundating coastal regions. The Gibe III dam and related irrigation projects for commercial farming in Ethiopia are two examples of large-scale infrastructure development upstream that has made this natural weakness worse. The dam's control of the Omo River's flow has changed the natural flood pulse that is important for ecosystems downstream.

The most serious and immediate effects of Lake Turkana's expansion have been felt along the eastern and northern shores, where the gentle terrain and high human dependence on near-shore livelihoods have made people more vulnerable. Loiyangalani, Moite, and Illeret are three communities that each have several beach management units (BMUs) that do artisanal fishing. These communities have all had fish landing sites, markets, and settlements that keep flooding. All of these places have said that they have lost landing infrastructure and that community assets have been damaged because the shoreline is moving forward and pastoralists have less access to grazing land. This means that there are pastoral and agro-fishing households in these areas that can't adapt very well, which makes the social and economic effects of the rising waters even worse.

Poor infrastructure, weak early-warning systems, and few options for diversifying their income have made it hard for communities to cope with flooding. They have had to move or leave flooded areas without any long-term options. This pattern shows how important it is to do a full environmental and climate risk assessment to find assets that are at risk, figure out how bad the risks are, and come up with ways to reduce and adapt to them. This assessment was therefore necessary to help the people who were affected, guide planning at the county level, and support long-term resilience measures in the vulnerable lakeshore communities of Marsabit County.

II. Assessment Objectives

This assessment sought to move beyond lake-wide analyses by providing a site-specific risk assessment for the most affected shoreline communities. The objectives were to:

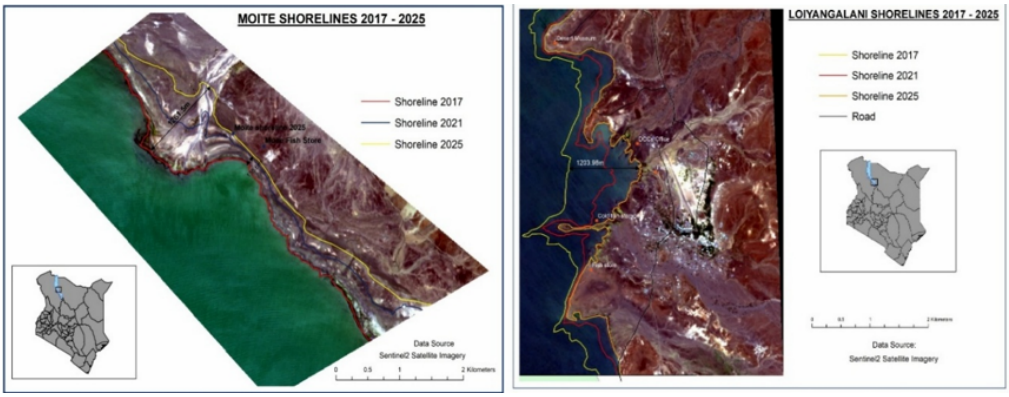
1. Evaluate the spatial expansion and temporal dynamics of Lake Turkana’s rising water levels in Loiyangalani, Moite, and Illeret.
2. Identify and document exposed elements, including populations, livelihoods, infrastructure, and ecosystems.
3. Analyse the livelihood and economic loses and damages of lake expansion and associated displacement.
4. Assess social and gender dimensions of vulnerability, focusing on women, youth, and marginalised groups.
5. Develop actionable, socially inclusive recommendations for adaptation, risk reduction, and resilience building.

III. Study Methodology And Study Area

The assessment adopted a mixed-methods, participatory, and spatially integrated approach, combining GIS-based shoreline analysis with qualitative socio-economic inquiry.

Geospatial Analysis

Historical and recent landsat satellite imagery (2017–2025) was analysed to map shoreline change, quantify rates of lake expansion, and identify high-risk zones. Shoreline positions were overlaid with spatial layers representing settlements, infrastructure, and ecological assets to assess exposure. From the assessment, it is very clear that there is progressive water increase as shown in the figures below. The rise has a greater impact on the social and economic aspects of communities living along the shorelines



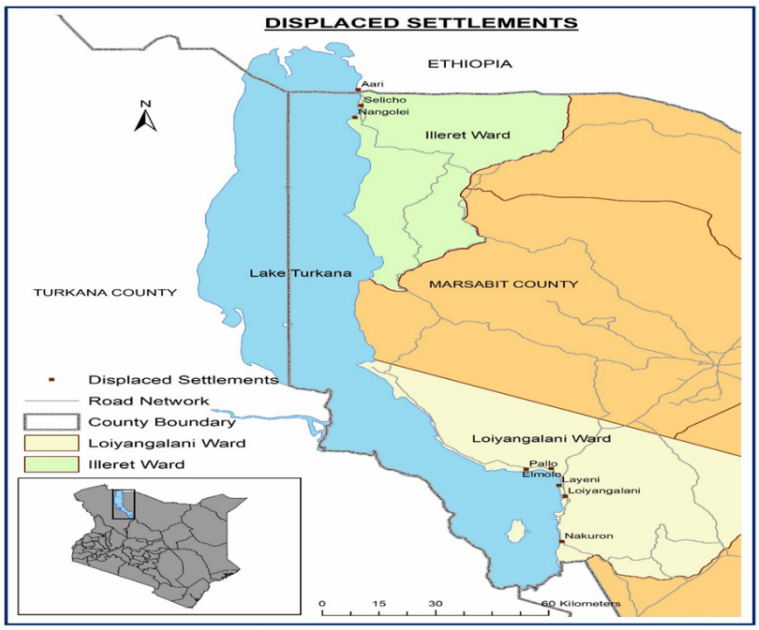
Participatory Mapping and Community Engagement

Participatory mapping, transect walks, focus group discussions, and key informant interviews were conducted across the three sites. Community members validated satellite-derived findings and contributed local knowledge on historical shoreline positions, livelihood losses, and adaptive responses.

Institutional and BMU Data

Data from 10 Beach Management Units were analysed to assess livelihood dependence, gender composition, infrastructure loss, and governance capacity. Each BMU was georeferenced and documented through photographs and field observations.

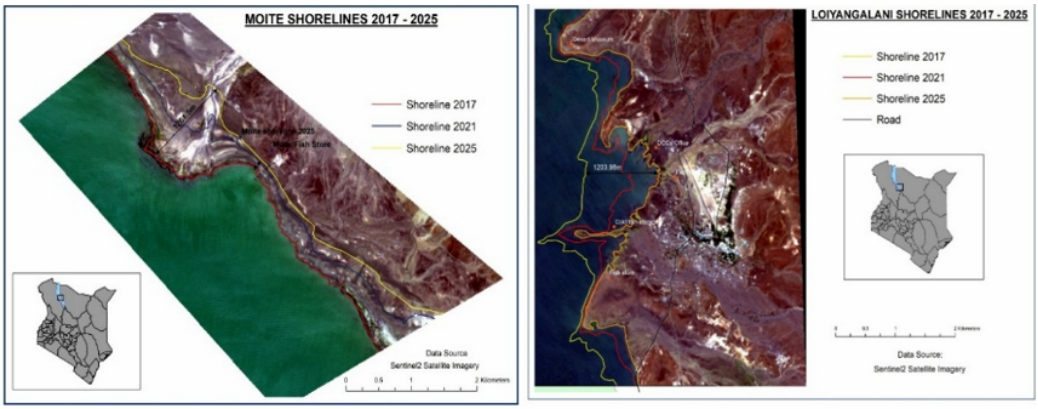
The assessment was carried out along the shore of the lakes visiting villages in Loiyangalani, Moite and Illeret. The site selection was based of prioritization of hot spot to get real impact of the raising water**.** Lake Turkana is growing and rising, which is a problem not only for water flow but also for social and ecological systems. As the lake's edge moves further inland, it comes into contact with more and more settlements, ways of making a living, important infrastructure, and delicate ecosystems. This intersection creates intersection layers at the three chosen sites that decide how much the communities and ecosystems will be affected. A thorough inventory of many exposed assets was found to be a good way to measure risk, come up with ways to reduce it, and decide which adaptations to make first. Below are the villages that are affected



IV. Spatial Expansion And Temporal Dynamics

Temporal Trends (2017–2025)

Satellite analysis shows a non-linear rise in lake levels, with relatively moderate increases between 2015 and 2018, followed by rapid acceleration from 2019 onwards. These surges correspond with periods of intensified rainfall in the Omo Basin and dam filling phases. Community observations closely align with satellite-derived trends, confirming distinct pulses of rapid lake rise rather than a steady linear increase.



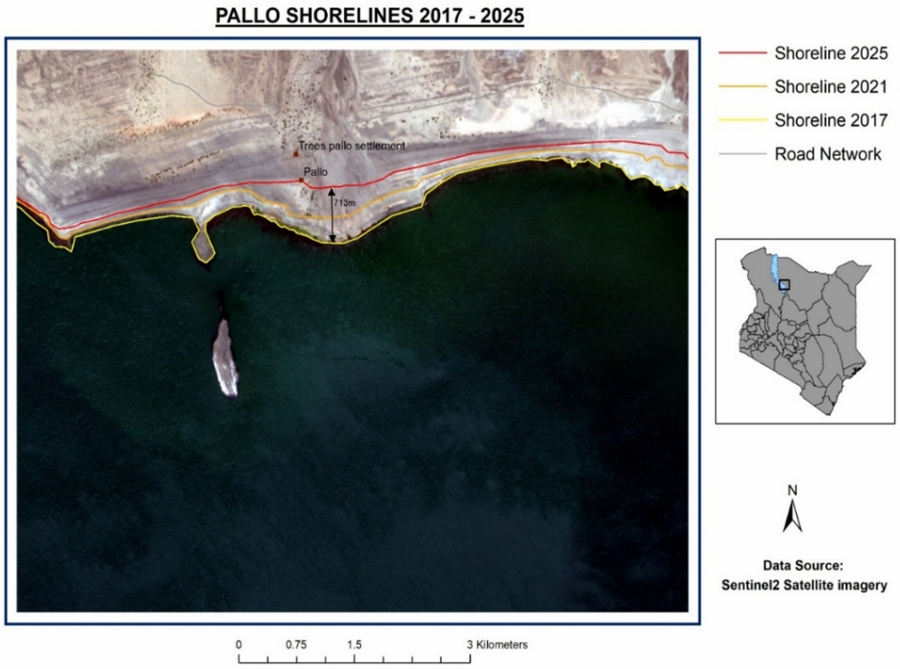
Spatial Expansion

Lake encroachment has been uneven across sites, reflecting local topography. Low-lying areas around Loiyangalani and Pallo experienced the greatest inland advance, exceeding 1.2 km in some locations. Illeret's deltaic zones suffered extensive inundation of fertile grazing and settlement areas, while Moite experienced significant but more spatially constrained flooding.

Projected Future Trends

Displaced settlements were observed in Nakuron, Loiyangalani, Komote, Layeni, Pallo, and Ilolo. The greatest shoreline recession occurred in Pallo, where the lake had advanced by up to 1.2 km from its 2017 shoreline position. Several water sources were affected, including a spring in Pallo and a water kiosk in Komote. However, new desalination facilities have since been established in Komote and Layeni, partially offsetting the loss of these freshwater sources.

At the observed rate of approximately 150 metres per year, continued lake expansion over the next decade will result in further displacement of settlements, loss of infrastructure, and ecological transformation unless mitigation and managed retreat measures are implemented.



Exposure, Impacts, and Risk Assessment

Exposed human population

The lake's expansion has exposed human populations, livelihoods, infrastructure, and ecosystems to systemic risk. Over 9,000 people are affected, with 2,504 BMU members facing direct livelihood disruption. Roads, schools, health centres, freshwater sources, and grazing lands are among the most severely impacted assets.

The rising waters of Lake Turkana have directly affected a large and vulnerable human population at all three assessment sites. The patterns of vulnerability are very different for different social groups. We can better understand the specific effects by looking at how BMU members who are directly affected because of their fishing livelihoods are exposed, as shown in the table below.

Table 1: Documented exposure of BMU members by site

Study site	Total BMU Members	Male members	Female Members
Loiyangalani	1394	977	417
Illeret	950	538	412
Moite	160	127	33
TOTAL	**2504**	**1642**	**862**

The table shows that a lot of people whose jobs depend on the lake have been directly affected by the rising waters. The Beach Management Units data shows that more than 2504 active BMU members, including 1642 men (66%) and 862 women (34%), were directly affected by the shoreline encroachment. The exposure is mostly in one area, with the Loiyangalani site (and nearby BMUs) having the most members (1,394), followed by Illeret (950 members) and Moite (160 members). There is a clear difference between men and women when it comes to managing formal resources in Loiyangalani. There are 66.4% men and only 33.6% women in the BMU. This difference is even more clear in Moite and Loiyangarani, where fewer than 30% of the people are women. This demonstrates that women are structurally disadvantaged in acquiring and managing fishery-related assets. This measured information about the fishing community that was affected is a good place to start when trying to figure out how big the problems with people's livelihoods are because the lake is growing.

In general, the quantified exposure shows how big the livelihood crisis is. The flooding of fishing infrastructure and disruption of the value directly threaten the economic security of 2504 people and their dependents, who make up the core of the fishing community in the assessment areas. The pastoralist population is also affected, with them showing the highest rates of displacement. Many households in the Illeret and Moite sites have had to move because they lost grazing land. As a result, the other areas are now too crowded.

Risk assessment matrix and prioritized register

Risk analysis identified three extreme risks and five high-priority risks, including livelihood collapse, public health emergencies, cultural loss, education system failure, isolation, conflict, and mental health crises. The thorough risk assessment of the 18 possible future risks led to the creation of a prioritised risk register of the eight most important threats to the communities along the Lake Turkana shoreline. Below is a matrix that combines both quantitative scoring and qualitative description to help people make decisions based on how likely they are to happen and how bad their effects could be.

Table 2. Climate Risk Assessment Matrix for Lake Turkana Shoreline Communities

Risk ID	Risk description and analysis	Likelihood	Impact	Risk Score	Priority level
R1	Collapse of pastoral livelihoods due to permanent loss of all the remaining grazing land leading to widespread famine	5	5	25	Extreme
R2	Major disease outbreak such as cholera, dysentery from complete lack of clean water and sanitation facility.	5	4	20	Extreme
R3	Irreversible loss of El Molo cultural heritage and community disintegration from total displacement	4	5	20	Extreme
R4	Permanent closure of all local schools due to flooding and inaccessibility thus creating a lost generation without education	4	4	16	High
R5	Total isolation of communities from markets and emergency services after final road connections are severed	4	3	12	High
R6	Resource based conflicts between communities over access to shrinking pastures and water points	3	4	12	High
R7	Total collapse of the fishing economy from ecosystem changes and loss of all landing sites	3	4	12	High
R8	Severe mental health crisis due to trauma, loss, of identify and hopelessness especially among the youth	3	4	12	High

Scale:

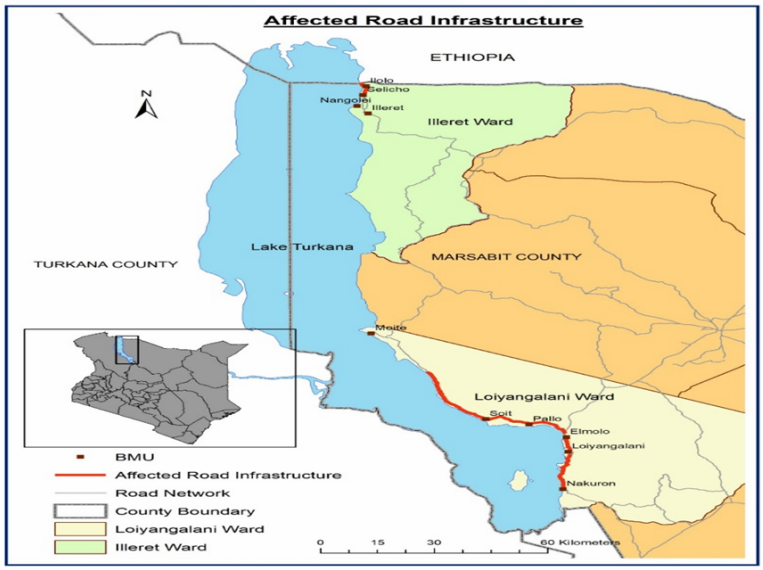
Likelihood: 1=very unlikely, 2=unlikely, 3=possible, 4=likely, 5=very likely

Impact: 1=insignificant, 2=minor, 3=moderate, 4=major, 5=catastrophic

The risk matrix analysis shows three risks that are of the highest priority (score 20-25) and pose a threat to the communities' existence. The first two pose an immediate threat to physical survival via starvation and disease, while the third endangers the total cultural extinction of the El Molo people. The extreme risks all have the same effect on the survival of the community: they can't be undone. These need a lot of help right away.

Five high-priority risks (12-16), on the other hand, would cause society to break down in the long term and make it impossible for it to grow. They want action right away and in a planned way. The high-priority risks aren't as bad right away, but they could quickly get worse because they have a lot of potential to spread. For instance, if education, the economy, and mental health all fell apart, along with isolation and conflict, it would create a cycle of poverty and vulnerability that people couldn't escape.

The spatial distribution of risks indicates a concentration in Loiyangalani for infrastructure-related risks, while livelihood- and health-related risks are distributed broadly across all sites.

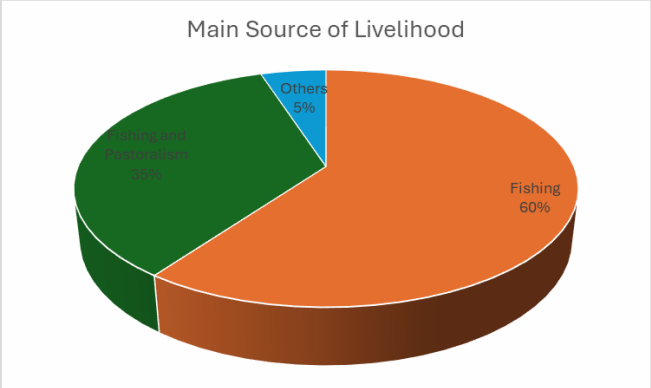


Impacts on Livelihoods and Economic Vulnerability

Fishing and pastoralism the backbone of local economies have been severely undermined. Daily fish catches have declined by over 50%, while the loss of dry-season grazing has increased livestock mortality and food insecurity. Market isolation, infrastructure damage, and rising transport costs have contributed to inflation and declining household incomes.

Livelihood loses

Fishing- The rising water levels of Lake Turkana have directly affected large and vulnerable human populations across all three assessment sites. However, patterns of vulnerability differ significantly among social groups. The majority of respondents (60%) depend on fishing as their primary livelihood, 35% fishing and pastoralism, and 5% others (small-scale business, casual work, house help). Fishing activities have been severely impacted by the rising water levels, as fish have moved into deeper waters that require modern fishing gear, which many fishers cannot afford. In addition, traditional fish breeding sites have been disrupted, forcing some fishers to resort to illegal fishing gear in order to sustain their livelihoods.



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The table shows that a lot of people whose jobs depend on the lake have been directly affected by the rising waters. The Beach Management Units data shows that more than 2504 active BMU members, including 1642 men (66%) and 862 women (34%), were directly affected by the shoreline encroachment. The assessment recorded devastating exposure to essential livelihood systems and economic resources. The exposure of livelihood systems has caused an economic crisis. The fisheries sector has been severely affected, with 12 major fish landing beaches completely underwater and 3 community fish cooling facilities no longer working. The BMUs said that the number of fish they caught each day dropped by an average of 55% because they couldn't get to the lake and because the lake's ecosystem changed.

Before the rise in water levels, the Loiyangalani BMU was able to operate eight lorries per month, each carrying 30 tonnes of fish, making two trips per week. During this period, the BMU could sell 40 bales of medium-sized tilapia per trip**,** each bale fetching KSh 120,000**,** generating KSh 4,800,000 per trip. This amounted to a total monthly income of KSh 38,400,000 from eight trips.

After the water level rose, operations declined drastically. The BMU could only manage a maximum of three lorries per month, each carrying the same 30 tonnes of fish. In addition, the price per bale dropped from KSh 120,000 to KSh 90,000**,** resulting in total monthly sales of only KSh 10,800,000**.**

Based on this assessment, the Loiyangalani BMU is experiencing **a** monthly loss of KSh 27,600,000 (approximately $213,953), which translates to an annual loss of KSh 331,200,000 (approximately $256,744)**.**

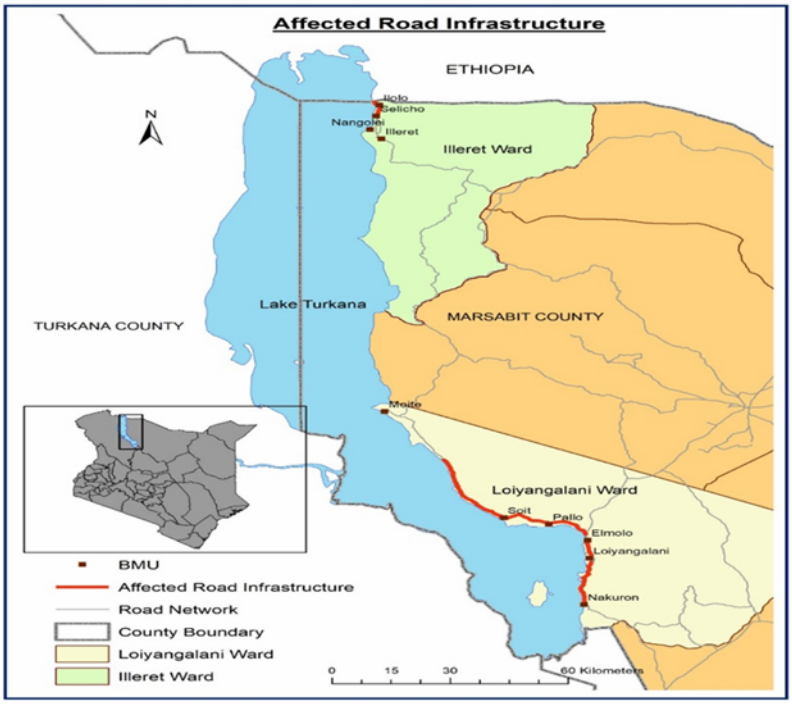
In general, the quantified exposure shows how big the livelihood crisis is. The flooding of fishing infrastructure and disruption of the value directly threaten the economic security of 2504 people and their dependents, who make up the core of the fishing community in the assessment areas.

Photos of Submerged cold chains and Fish Landing sites

Infrastructure damage
Affected /submerged roads

From the assessment and as indicated on the map below, several access roads are submerged, cutting off communities, while critical infrastructure has been severely damaged. The cost of reconstructing or rerouting these roads is extremely high, making access to some villages, such as El Molo, difficult and expensive. As a result, food commodity prices have increased, and access to essential services, including healthcare, has been significantly affected the exposure of critical infrastructure is widespread and has seriously hurt the delivery of basic services. The transport network has been visibly damaged and broken, with almost 16 kilometres of main and secondary roads now permanently underwater or severely damaged. This includes the important Loiyangalani-Moite road section, Sarima-Loiyangalani section, which, because it is no longer there, has made it take hours longer to get to major settlements, cutting off access to markets and even emergency medical care.

From the assessment findings, it costs approximately KSh 1million per kilometre to rehabilitate a murram road (as per County road specification), which translates to an estimated KSh 16 million for the sections currently submerged. Due to the absence of a resettlement plan, the government and other non-state actors have been forced to relocate the road four times for the last 8 years. There are clear indications that the newly rerouted sections remain at high risk of submergence again.



Damage on Cold chain, Landing sites and boats

Fish production in Kenya contributes to 5% of GDP[1], and the bulk of fish comes from Lake Victoria. Lake Turkana contributes 6%[2] of this bulk of fish and considering that 70% of Lake Turkana belongs to Marsabit County. Most of the cold chains are constructed along the shore of the lake to sustain the fish value chain and strengthen livelihoods.

The exposure of livelihood systems has caused an economic crisis. The fisheries sector has been severely affected, with 12 major fish landing beaches completely underwater and 3 community fish cooling facilities no longer working. The BMUs said that the number of fish they caught each day dropped by an average of 55% because they couldn't get to the lake and because the lake's ecosystem changed.

According to the Bill of Quantities obtained from the fisheries sector, the construction cost of the facility was KSh 38 million. The structure also included mini cold chain units strategically placed along the shoreline to supply fish to the main cold chain facility.

1
S enges in the Lake Turkana Fishery: Building a
2
T *changes in water inflow on the fishes of Lake* of New York at Stony Brook)

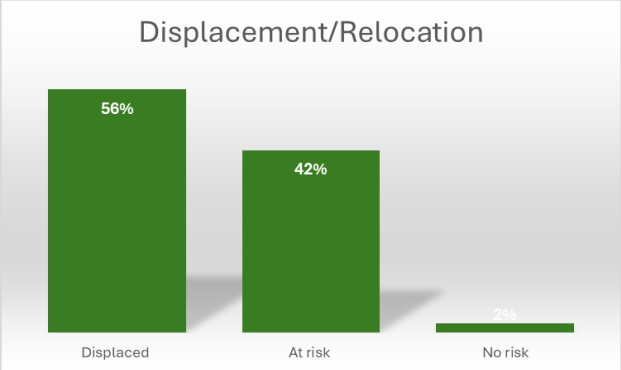
The photo above shows a submerged cold chain facility.

Displacement and Housing Lost

People are now moving away from the three assessment sites. Interviews with people in the community estimate that a large number of households are either partially or fully displaced, especially in Loiyangalani and El Molo Bay. In Komote (El Molo), families are moving up into the hills. These movements are mostly unplanned, which makes people more vulnerable in other ways, like not having enough shelter, poor sanitation, and being exposed to vector-borne diseases like dysentery.

The communities along the shores of Lake Turkana are already experiencing multiple climate shocks such as drought, human and livestock diseases, and erratic rainfall. The rising water levels have further worsened the situation. The cost of relocation is very high. From the assessment, 56% of respondents indicated that they have relocated from their original settlements**,** 42% reported that their houses are at risk of submergence, and 2% stated that they are not at risk**.**

With 56% of respondents (56% of 2,504)**,** a total of 1,402 households have relocated from their original homesteads. Households are forced to carry only what can be dismantled, leaving behind valuable assets. According to the respondents, the average cost of relocation is approximately KSh 380,000 per household. Therefore, the total estimated losses incurred by the 1,402 households since the onset of the water rise amount to KSh 532,760,000(4,129,922 USD)



Losing the lakeshore has also hurt social cohesion. Palo's fishermen and pastoralists used to work together, but now they are competing more and more for housing and access to water points that have been flooded. There have also been problems between the Turkana and El Molo overfishing in certain areas of the lake that are further back in the Palo BMU. This has led to new local conflicts as the El Molo contest moved into cultural sites.

Increase cost of living

The submergence of roads has cut off several communities from easy access to food commodities. Villages such as Komote have been completely isolated after roads, schools, health centres, and churches were submerged by rising water levels. As a result, these communities are now effectively living on islands.

This isolation has significantly increased the cost of living. Residents are forced to use boats at cost of 300Ksh one way to reach dry land to connect to Loyangalani town, which is approximately 25 km away, to access essential food commodities such as maize, beans, and maize flour. The cost of boat transport, combined with long travel distances, has led to sharp increases in food prices, placing a heavy burden on already vulnerable households.

Below are the prices of key food commodities before and after the rise in water levels**,** illustrating the impact on household food access and affordability.

Food commodities	Price Before Water Rise	Price after water Rise
Maize flour 5kg	380	670
Beans 1kg	180	300
Sugar 1kg	120	250

Access to Essential Services, that is, Health and Education

The rise in water levels has also had a severe impact on health and education services**.** Patients are now forced to travel longer distances and incur higher transport costs to reach health facilities, often relying on boats, which delays access to essential medical care and increases health risks.

Similarly, children face significant barriers to accessing education. Many are unable to reach schools due to submerged routes, unsafe travel conditions, and the high cost of transport. As a result, school attendance has declined, with some children dropping out entirely.

Overall, these disruptions have led to tertiary impacts, including deepening poverty, reduced access to basic services, and increased school dropout rates as education becomes both dangerous and unaffordable for affected households.

Social and Gender Dimensions of Vulnerability

Women and youth face **disproportionate burdens** due to limited asset ownership, restricted participation in decision-making, and increased unpaid care responsibilities. While Illeret exhibits stronger female participation through savings groups, leadership positions remain male-dominated across all BMUs. Youth face rising unemployment, displacement-related trauma, and limited access to education.

V. Conclusions And Recommendations

The rising waters of Lake Turkana constitute a systemic climate risk that threatens livelihoods, social cohesion, and cultural survival in Marsabit County. Addressing this crisis requires:

Immediate actions: hazard zoning, managed resettlement, emergency water systems, and protection of vulnerable groups.

Medium-term measures: climate-resilient fisheries infrastructure, livelihood diversification, gender-inclusive governance, and improved market access.

Long-term strategies: institutional strengthening, ecosystem protection, and integration of community savings groups into formal financial systems.

Without decisive and coordinated action, the impacts will intensify, leading to irreversible social and ecological losses. Conversely, timely, inclusive, and spatially informed interventions can transform this crisis into an opportunity for resilient development along Lake Turkana's shores.

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