The Correlation between Climate Change, Environmental Degradation, and Public Health: A Case Study of the Emergence of New Malaria Species Anopheles Stephensi in Turkana County, Kenya.

Written by Lorna Makena

Abstract

The Anopheles Stephensi are a group of mosquitoes known for their role in transmitting the malaria parasite (Plasmodium) to humans. Native to South Asian countries and parts of the Arabian Peninsula India, Anopheles Stephensi mosquitoes thrive around sewers and dirty water, making them more adaptable to urban and peri urban areas. Anopheles was first discovered in Africa in Ethiopia and Djibouti in 2012, countries that border Kenya.

For the Anopheles Stephensi to be discovered in Kenya it means that the conditions in the area were favorable for its breeding. This factors are climate change in terms of rainfall and temperature, land and environmental degradation and human activities. This study aims to examine the intricate relationship on how climate change affects both land and environment degradation in which leads to the favorable breeding conditions of Anopheles Stephensi.

One unique characteristics of Anopheles Stephensi that sets it apart from other mosquito species is that it thrives in urban and peri urban areas. Scientifically researched and known, urban areas are mosquito free zones and there is little to no chance of contracting malaria in an urban setting such as Nairobi.

If Anopheles stephensi were to spread in a city like Nairobi, the consequences would be serious. First, malaria could spread to the inner-city areas. Until now, these areas have had little or no transmission and their populations have not acquired immunity against malaria. Secondly, urban development would no longer be assumed to contribute to malaria elimination.

Urbanisation has added to many health problems. But it has tended to “build out” malaria through better housing and gradual pollution of the landscape. Traditional malaria vectors can’t breed in small containers or in water with organic pollution. The new invasive species may mean that the development of new suburbs is building malaria into the landscape.

Therefore there is a need to examine and investigate the conditions favoring the breeding of Anopheles Stephensi in which can proceed to ways to curb or contain this mosquito species from spreading.

Introduction

Background

The relationship between climate change, environmental degradation, and public health is complex, forming a multidimensional interconnection of challenges with profound implications for global well-being. Climate change, marked by rising temperatures and erratic weather patterns, contributes to environmental degradation through processes such as deforestation and loss of biodiversity. This environmental decline, in turn, adversely affects public health on various fronts.

Water scarcity, intensified by changing climate conditions and environmental stress, amplifies the risk of waterborne diseases, posing a significant threat to communities that lack access to clean water sources. Additionally, altered landscapes and disrupted ecosystems create fertile grounds for the proliferation of disease vectors, leading to an increased prevalence of vector-borne illnesses like malaria and dengue fever. The direct health impacts of climate change, including heat-related illnesses and the changing geographic distribution of infectious diseases, further exacerbate the strain on public health systems.

Climate Change and Environmental Degradation:

a. Altered Weather Patterns:

- **Climate change** leads to shifts in global weather patterns, resulting in phenomena such as extreme temperatures, erratic rainfall, and increased frequency and intensity of weather events like hurricanes and droughts.

b. Impact on Ecosystems:

- These changes contribute to **environmental degradation** by disrupting ecosystems, causing habitat loss, and threatening biodiversity. Deforestation, desertification, and loss of wetlands are common consequences.

Environmental Degradation and Public Health:

a. Water Scarcity:

- **Environmental degradation**, particularly deforestation and soil erosion, can lead to diminished water quality and scarcity. Contaminated water sources contribute to the spread of waterborne diseases such as cholera, typhoid, and dysentery.

b. Vector-Borne Diseases:

- Altered landscapes and climate conditions provide conducive environments for disease vectors. Stagnant water and increased temperatures foster the breeding of mosquitoes, contributing to the spread of vector-borne diseases like malaria and dengue fever.

c. Air Pollution:

- Deforestation and industrial activities associated with environmental degradation contribute to **air pollution**. Poor air quality is linked to respiratory diseases, including asthma and chronic obstructive pulmonary disease (COPD).

3. Climate Change and Public Health:

a. Heat-Related Illnesses:

- Direct impacts of **climate change on public health** include an increased frequency and intensity of heatwaves, leading to heat-related illnesses and fatalities, particularly in vulnerable populations.

b. Spread of Infectious Diseases:

- Changing climate conditions affect the geographic distribution of diseases. **Vector-borne diseases**, traditionally confined to specific regions, may spread to new areas as warming temperatures create suitable habitats for disease vectors.

c. Food Security:

- Altered precipitation patterns and extreme weather events influence **agricultural productivity**, affecting food security. Crop failures and food shortages can lead to malnutrition and related health issues.

4. Feedback Loops:

a. Vicious Cycles:

- Climate change and environmental degradation can create feedback loops, where each factor exacerbates the other. For example, deforestation contributes to climate change by reducing the number of trees that absorb carbon dioxide.

b. Vulnerable Populations:

- **Vulnerable populations**, including those in low-income countries and marginalized communities, often bear the brunt of these interconnected challenges, facing heightened health risks due to inadequate resources and limited access to healthcare

Public health

Anopheles Mosquitoes and Malaria Transmission

Anopheles mosquitoes are a group of mosquitoes known for their role in transmitting the malaria parasite (Plasmodium) to humans. Native to South Asia and parts of the Arabian Peninsula India, Anopheles stephensi mosquitoes thrive around sewers and dirty water, making them more adaptable to urban areas.

First discovered in Africa in Ethiopia and Djibouti in 2012, which border Kenya to the north and northwest. Kenya is the third African country in which it as discovered. Anopheles stephensi are a threat to vulnerable groups such as infants, young children and the elderly.

Conditions that support the breeding ground of anopheles stephensi

1. **Temperature:** Anopheles stephensi mosquitoes prefer warmer temperatures. They thrive in areas where the temperature remains consistently high, typically between 25 to 30 degrees Celsius (77 to 86 degrees Fahrenheit). Warm temperatures accelerate the development of mosquito larvae.
2. **Stagnant Water:** Anopheles mosquitoes, like many other mosquito species, lay their eggs in stagnant or slow-moving water. Common breeding sites include ponds, puddles, open drains, and containers that collect rainwater. The larvae need still water to develop, and these breeding sites provide a suitable environment for the mosquito life cycle.
3. **Urban and Peri-Urban Areas:** Anopheles stephensi has adapted to urban environments and can breed in man-made containers found in urban and peri-urban areas. This adaptation makes it a significant concern for malaria transmission in densely populated regions.
4. **Artificial Containers:** Anopheles stephensi is known to breed in a variety of artificial containers, such as water storage tanks, barrels, pots, and discarded tires. These containers provide suitable breeding sites, especially in urban settings where water storage and improper waste disposal are common.
5. **Poor Drainage:** In areas with poor drainage, rainwater can accumulate and create breeding grounds for mosquitoes. Clogged drains and improper water management contribute to the persistence of stagnant water, providing an ideal environment for mosquito larvae.
6. **Vegetation and Shaded Areas:** Anopheles stephensi larvae may be found in shaded areas with vegetation, as these areas can provide protection and maintain suitable moisture levels for breeding.
7. **Human Activities:** Human activities that contribute to the creation of standing water, such as irrigation practices, construction sites, and improper waste disposal, can significantly increase the potential breeding sites for Anopheles stephensi.

Motivation and problem statement

Malaria is one of the leading causes of disease related deaths in Kenya especially in young children below the age of 5 years. This growing threat in Kenya is being driven by climate change, which causes land and environment degradation affected by human activities. Thus, varies methods and solutions should be applied to help monitor and curb malaria transmission starting by having the information on what favors breeding grounds to eliminate them.

Anopheles Stephensi was discovered in Kenya in 2022. This means that the conditions required for its breeding were favorable. This then shows that it is important to investigate and analyze the factors that were conducive for this new mosquito species to breed in Kenya. This can be important in finding ways to curb and eliminate breeding grounds as Anopheles Stephensi thrives in urban settings in which have been considered malaria free zones.

Research Identification

The main aim of this research is to investigate the intricate relationship between climate change, environmental degradation and public health, and how these factors have contributed to the favorable breeding conditions of Anopheles Stephensi in Turkana County.

This is achievable through the following specific objectives:

Research Objectives

1) To investigate the climate change patterns in Turkana County
    - Investigate the historical and current climate patterns in Turkana County assessing temperature variations, Rainfall patterns and frequency of extreme weather conditions.
2) To analyze and assess environmental degradation including deforestation and changes in land use.
3) To investigate the spread of malaria cases in Turkana County including the socioeconomic factors contributing to the vulnerability of the population to malaria, assess poverty levels and access to healthcare
4) To investigate the spread of Anopheles Stephensi in Turkana including the factors that favor the breeding condition of Anopheles Stephensi in Turkana
5) Show the correlation through R squared analysis

Research questions

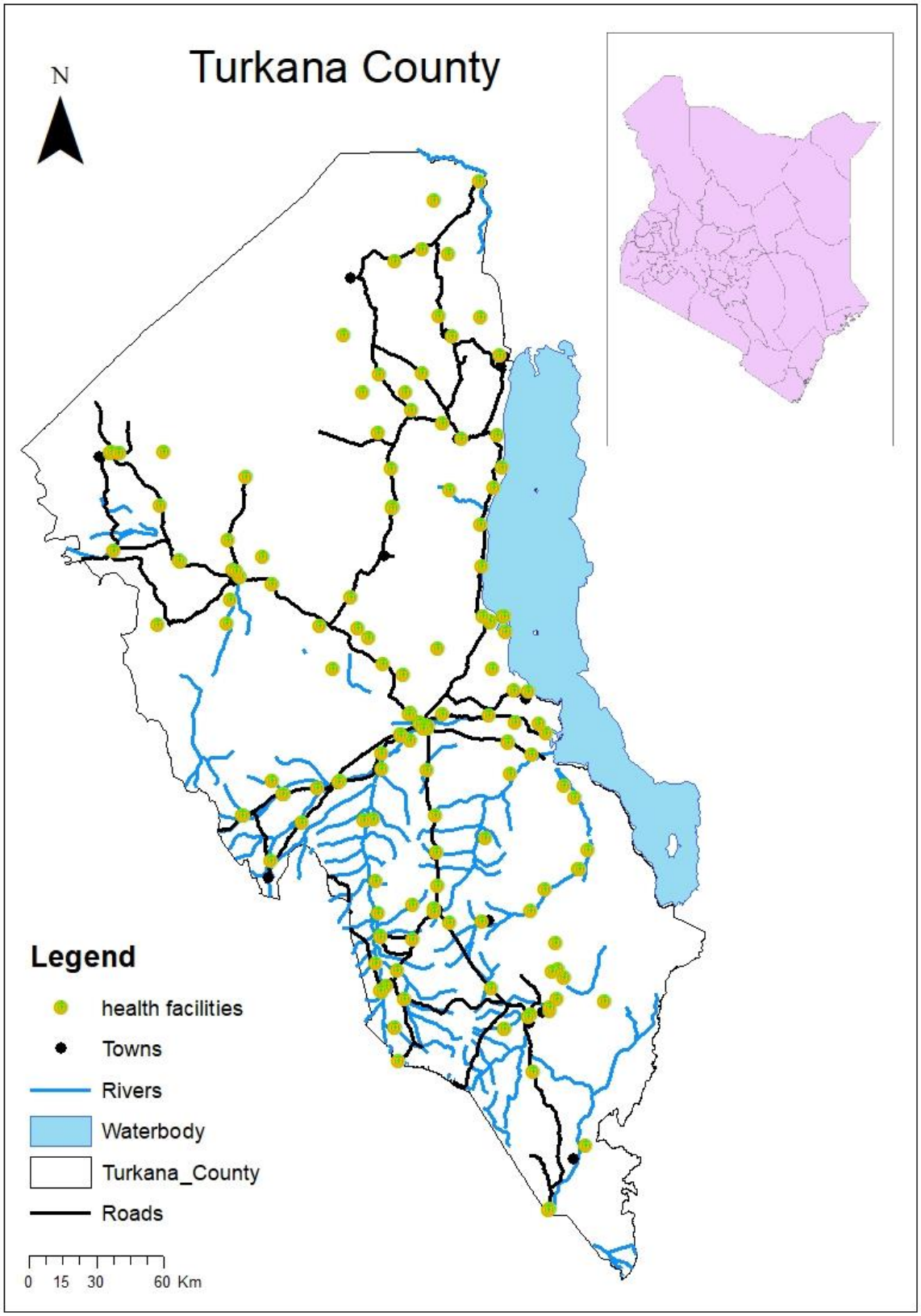
To find out how and why it is possible for Anopheles Stephensi to breed in Kenya:

a) What factors support its breeding?
b) How has climate influenced its breeding conditions?
c) How has environmental degradation in Turkana influenced its breeding?
d) How has human activities Contributed to its breeding?

Audience

The primary audience for this document are environmental and public health scientists and researchers involved in climate change adaptation, environmental conservation, and public health initiatives. The study aim is to examine factors favorable for Anopheles Stephensi in which can be a source to also find other countries or locations which can also be susceptible to the breeding conditions of the mosquito species.

Study Area


Turkana County
N
Legend
health facilities
Towns
Rivers
Waterbody
Turkana_County
Roads
0 15 30 60 Km

Turkana County covers 68,233 km2 of land and 2,279 km2 of water (KNBS, 2019b; Turkana County Government, 2013). It is the second-largest county in Kenya. It lies 1,138 meters above sea level (Turkana County Government, 2013). The county is located in the north-western part of Kenya.

Lake Turkana, located in the east of the county, is the world's largest permanent desert lake and lies 360 meters above sea level (Turkana County Government, 2018). The county borders Marsabit County to the east, West Pokot and Baringo Counties to the south, and Samburu County to the southeast.

It also borders Uganda to the west, South Sudan to the north and Ethiopia to the northeast (Turkana County Government, 2013). It lies between longitudes 34° 30' and 36° 40' east, and between latitudes 1° 30' and 5° 30' north. Turkana County is mostly arid, with a warm to hot climate. The southern areas are categorized as semihumid to semi-arid (Turkana County Government, 2018).

The temperature ranges from 20°C to 41°C, with a mean of 30.5°C (Turkana County Government, 2018). Turkana County has distinct agro-ecological zones that vary in humidity and temperature. The county has rivers, low-lying, open plains, and mountain ranges. There are three main rivers in Turkana County, and they all drain into Lake Turkana. The river Turkwel flows from Mt. Elgon at the border of Kenya and Uganda, the river Omo flows from southern Ethiopia, and the river Kerio flows from the Amasya Hills at the west of Lake Bogoria.

There are two rainy seasons: the long rainy season and the short rainy season. The former occurs between April and July, and the latter occurs between October and November. The county receives an annual average of 200 mm of rainfall. The months of January, February, and September are usually the driest months. Low rainfall and high temperatures, coupled with high rates of evapotranspiration, result in salt and hard pans on the soil surface. Because of this, only 30% of the county's soil is suitable for farming (Turkana County Government, 2018).

The county's rainfall is erratic and unreliable. Furthermore, heavy storms and catastrophic flash floods can occur. Heavy rains over short periods of time can also cause flooding.

Figure 2: Family preparing a meal in Turkana County

Climate Change in Turkana County:

1. **Temperature Increase:** Like many other regions globally, Turkana County has witnessed a rise in temperatures. This increase contributes to elevated evaporation rates and exacerbates water scarcity, affecting both agriculture and water availability for communities.

2. **Erratic Rainfall Patterns:** The County experiences unreliable and irregular rainfall patterns, leading to prolonged periods of drought and flash floods. Unpredictable rainfall has severe consequences for water sources, agriculture, and the overall well-being of the population.

3. **Increased Frequency of Extreme Weather Events:** Turkana County is vulnerable to extreme weather events, such as floods and storms. These events can have devastating effects on infrastructure, agriculture, and human settlements.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Nov	Oct	Dec	Year
Record high °C (°F)	38.0 (100.4)	39.0 (102.2)	39.0 (102.2)	38.0 (100.4)	37.0 (98.6)	37.0 (98.6)	36.0 (96.8)	36.0 (96.8)	38.0 (100.4)	37.0 (98.6)	37.0 (98.6)	37.0 (98.6)	39.0 (102.2)
Average high °C (°F)	35.13 (95.23)	36.12 (97.02)	35.7 (96.26)	33.9 (93.02)	33.22 (91.8)	32.78 (91.0)	32.03 (89.65)	32.42 (90.36)	33.82 (92.88)	34.34 (93.81)	33.63 (92.53)	34.01 (93.22)	33.93 (93.07)
Daily mean °C (°F)	31.55 (88.79)	32.47 (90.45)	32.38 (90.28)	30.83 (87.49)	30.32 (86.58)	29.89 (85.8)	29.12 (84.42)	29.4 (84.92)	30.55 (86.99)	31.2 (88.16)	30.62 (87.12)	30.87 (87.57)	30.77 (87.39)
Average low °C (°F)	25.87 (78.57)	26.85 (80.33)	27.47 (81.45)	26.62 (79.92)	26.37 (79.47)	25.97 (78.75)	25.43 (77.77)	25.46 (77.83)	26.0 (78.8)	26.75 (80.15)	26.17 (79.11)	25.97 (78.75)	26.24 (79.23)
Record low °C (°F)	12.0 (53.6)	20.0 (68.0)	21.0 (69.8)	17.0 (62.6)	22.0 (71.6)	22.0 (71.6)	20.0 (68.0)	18.0 (64.4)	22.0 (71.6)	22.0 (71.6)	21.0 (69.8)	20.0 (68.0)	12.0 (53.6)
Average precipitation mm (inches)	23.65 (0.93)	12.8 (0.5)	55.61 (2.19)	130.65 (5.14)	77.52 (3.05)	33.24 (1.31)	42.76 (1.68)	45.36 (1.79)	15.14 (0.6)	47.1 (1.85)	81.08 (3.19)	39.24 (1.54)	50.35 (1.98)
Average precipitation days (≥ 1.0 mm)	2.36	2.55	6.73	13.36	8.55	3.82	7.82	5.18	2.27	5.91	9.73	6.0	6.19
Average relative humidity (%)	33.72	34.54	39.66	49.47	49.19	44.61	44.99	44.09	40.75	42.22	46.53	40.98	42.56
Mean monthly sunshine hours	11.49	11.58	11.45	11.28	11.42	11.47	11.43	11.47	11.57	11.53	11.52	11.55	11.48

Figure 3: Climate data of Turkana County 2022

Historical Climate Data of Turkana County

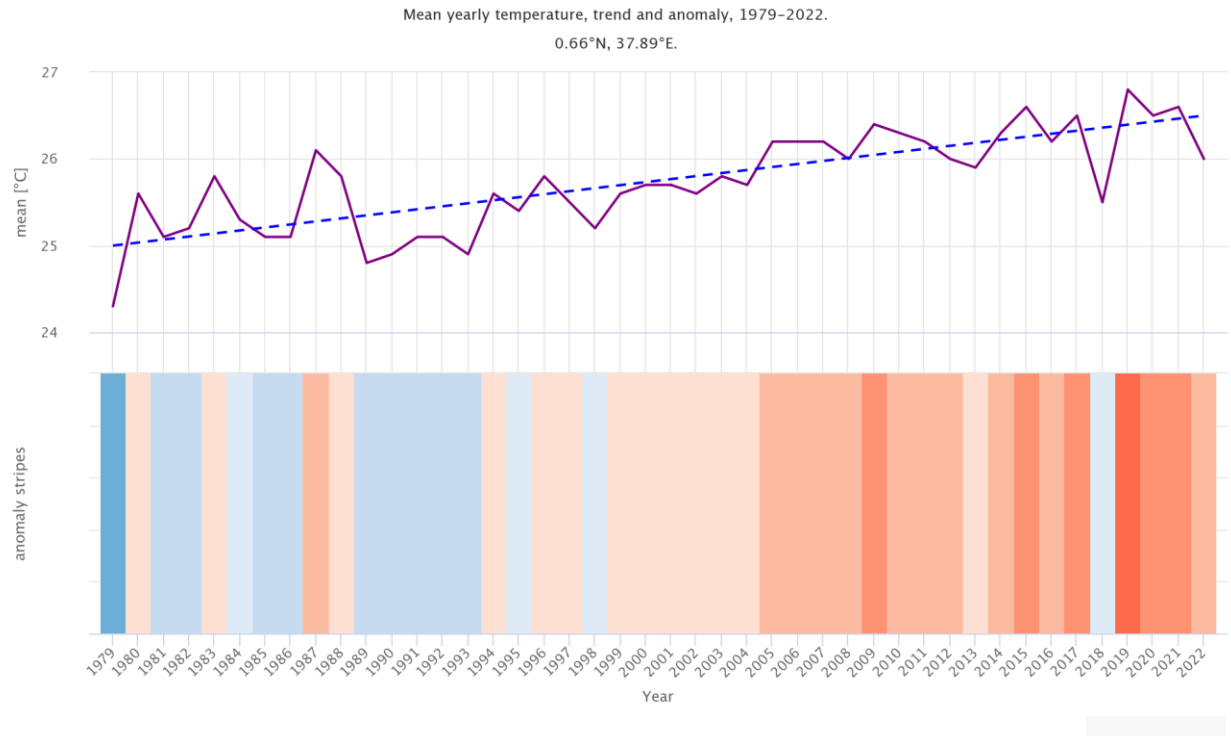


Figure 4: Yearly temperature graph of Turkana County

The top graph shows an estimate of the mean annual temperature for the larger region of Turkana. The dashed blue line is the linear climate change trend. If the trend line is going up from left to right, the temperature trend is positive and it is getting warmer in Turkana due to climate change. If it is horizontal, no clear trend is seen, and if it is going down, conditions in Turkana are becoming colder over time.

In the lower part the graph shows the so called warming stripes. Each colored stripe represents the average temperature for a year - blue for colder and red for warmer years.

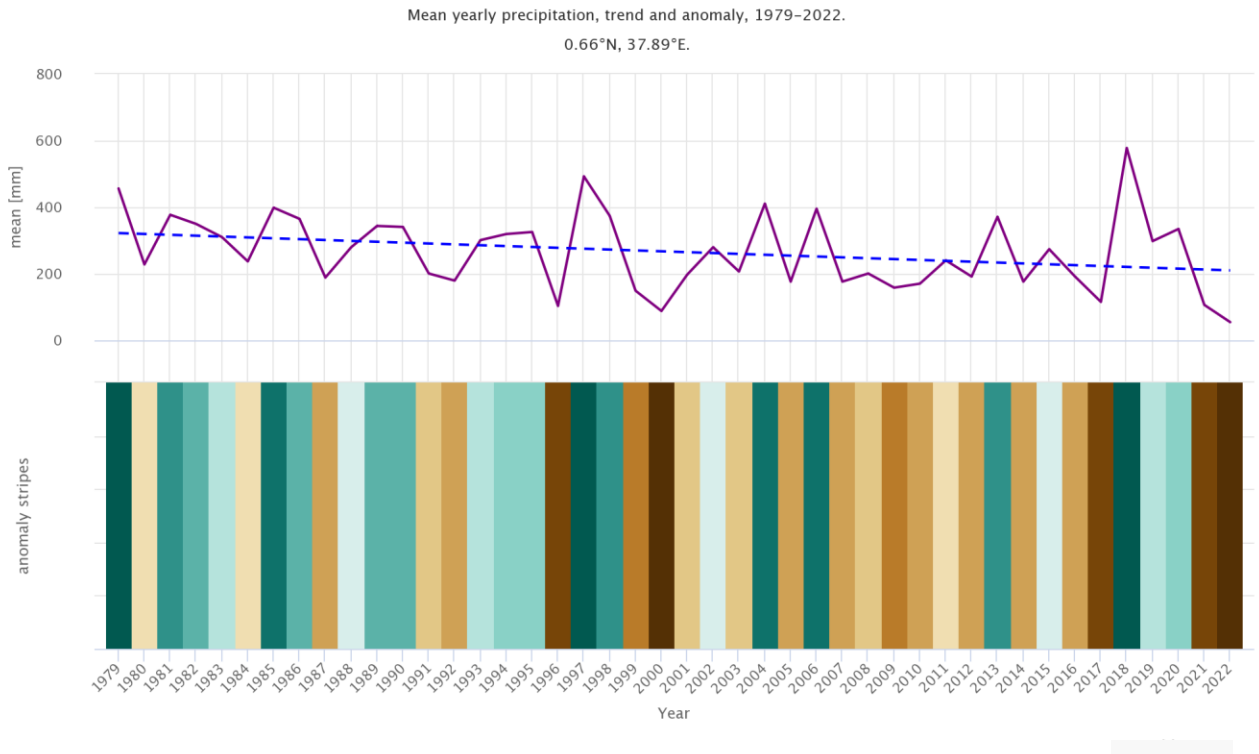


Figure 5: Yearly precipitation graph of Turkana

The top graph shows an estimate of mean total precipitation for the larger region of Turkana. The dashed blue line is the linear climate change trend. If the trend line is going up from left to right, the precipitation trend is positive and it is getting wetter in Turkana due to climate change. If it is horizontal, no clear trend is seen and if it is going down conditions are becoming drier in Turkana over time.

In the lower part the graph shows the so called precipitation stripes. Each colored stripe represents the total precipitation of a year - green for wetter and brown for drier years.

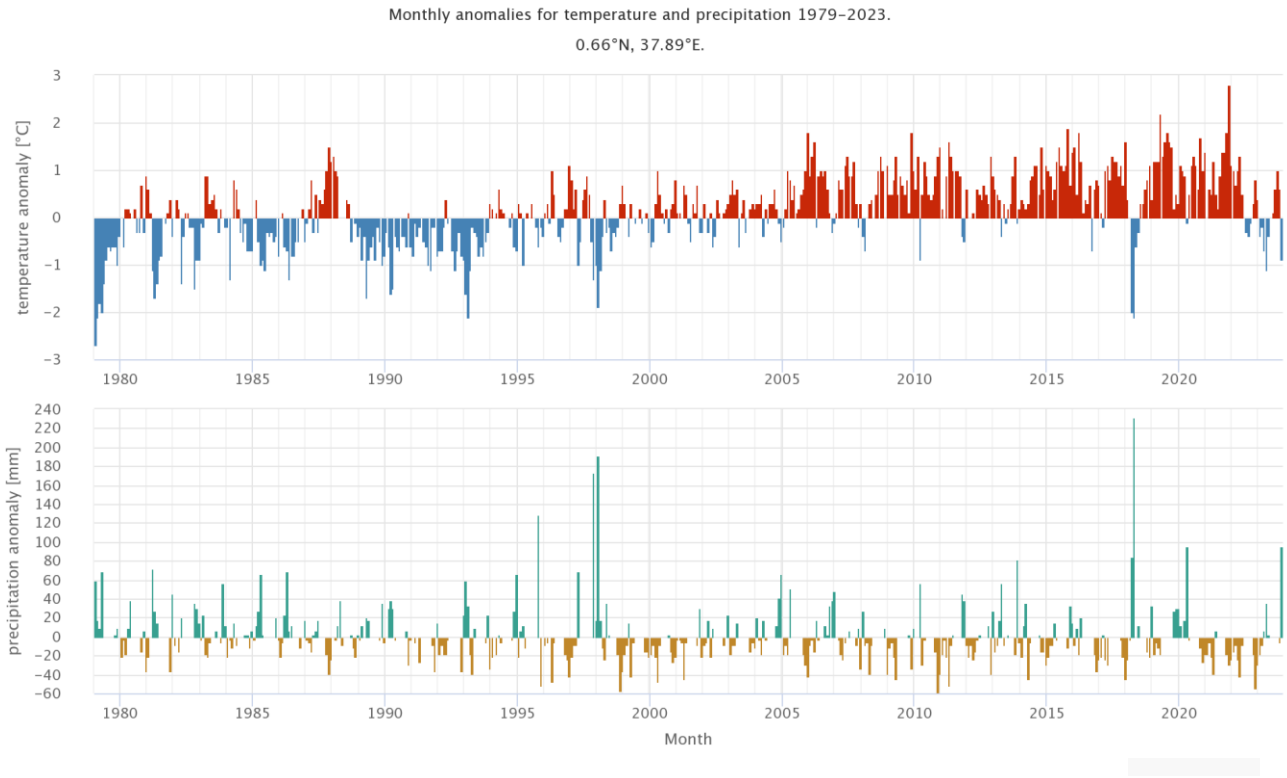


Figure 6: Yearly temperature and precipitation anomalies

The top graph shows the temperature anomaly for every month since 1979 up to now. The anomaly tells you by how much it was warmer or colder than the 30 year climate mean of 1980-2010. Thus, red months were warmer and blue months were colder than normal. In most locations, you will find an increase of warmer months over the years, which reflects the global warming associated with climate change.

The lower graph shows the precipitation anomaly for every month since 1979 up to now. The anomaly tells you if a month had more or less precipitation than the 30 year climate mean of 1980-2010. Thus, green months were wetter and brown months were drier than normal.

Environmental Degradation in Turkana County:

1. **Deforestation:** Over the years, there has been extensive deforestation in Turkana County, primarily due to unsustainable land use practices, such as logging and clearing land for agriculture. This loss of vegetation reduces the capacity of the ecosystem to retain water and contributes to soil erosion.

2. **Soil Erosion:** Deforestation, coupled with unsustainable agricultural practices, has led to soil erosion. The eroded soil, carried by wind or water, not only reduces the fertility of the land but also negatively impacts water quality.

3. **Desertification:** Turkana County is prone to desertification, a process where fertile land transforms into desert-like conditions. This phenomenon is exacerbated by overgrazing, deforestation, and prolonged droughts, posing a significant threat to local ecosystems and livelihoods.

4. **Water Scarcity:** The combination of erratic rainfall patterns, high evaporation rates, and over-extraction of water resources has resulted in severe water scarcity in Turkana County. This scarcity affects not only domestic water supply but also has implications for agriculture and livestock rearing.

Figure 7: Forest Degradation in Turkana

Figure 8: Lake Turkana

Figure 9: Lack of vegetation cover

Figure 10: Bare arid land

Land use land cover

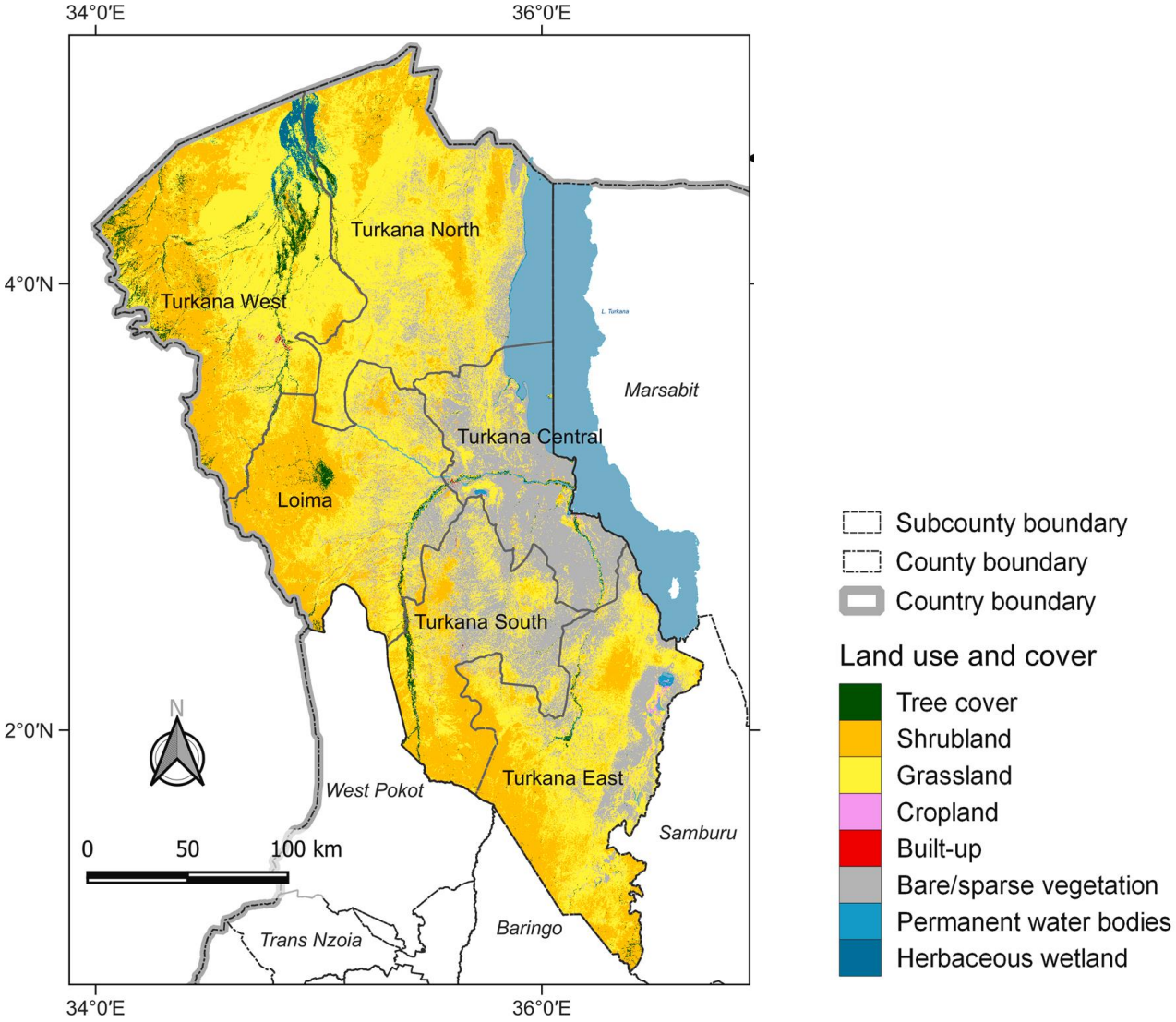


Figure 11: Land use and land cover change of Turkana County

Impact on Communities:

1. **Livelihood Challenges:** The pastoralist communities in Turkana heavily rely on livestock for their livelihoods. Climate change-induced factors such as drought and water scarcity pose significant challenges to the well-being of these communities by threatening the health and productivity of their livestock.

2. **Food Insecurity:** Erratic rainfall and environmental degradation contribute to reduced agricultural productivity, leading to food shortages. The reliance on rain-fed agriculture makes communities vulnerable to the impacts of climate variability.

3. **Health Concerns:** Limited access to clean water, coupled with changing climate patterns, contributes to health challenges. Waterborne diseases become more prevalent during periods of water scarcity, affecting the overall health of the population.

4. **Impact on Agriculture and Food Security***:* Crop failures lead to food shortages, and malnutrition becomes widespread. The compromised nutritional status of the population weakens immune systems, making individuals more susceptible to various diseases.

5. **Mental Health Implications:** Anxiety, stress, and depression become prevalent in a community grappling with the unpredictability of their environment and the ongoing battle for survival.

6. **Impacts on Livelihoods and Economic Stability:** Losses of livestock due to changing environmental conditions lead to economic instability, reducing access to healthcare and exacerbating existing health disparities.

Figure 12: Pastoral Communities in Turkana

Malaria Cases in Turkana County

Turkana County in northwestern Kenya was supposed to be the land that malaria forgot. An arid, windy region abutting Uganda, South Sudan and Ethiopia, its climate was thought to be too dry for the mosquitoes that harbor malaria-causing parasites, and thus it has been excluded from national efforts to prevent the spread of the disease.

Malaria is a significant public health concern in Turkana County, Kenya, with several factors and conditions contributing to the high incidence of malaria cases in the region. Understanding these factors is crucial for effective malaria control and prevention strategies. Here are some key factors and conditions that support the increase in malaria cases in Turkana:

1. **Climate and Environmental Conditions:**
    - **Hot and Arid Climate:** Turkana County has a predominantly hot and arid climate, which is conducive to the breeding of malaria vectors, particularly Anopheles mosquitoes. The warm temperatures accelerate the development of the malaria parasite within the mosquito, increasing the transmission rate.
2. **Water Bodies and Mosquito Breeding Sites:**
    - **Intermittent Rivers and Water Pans:** The region's intermittent rivers and water pans, which are prone to seasonal flooding, provide ideal breeding sites for mosquitoes. Stagnant water bodies serve as breeding grounds for Anopheles mosquitoes, leading to an increased mosquito population.
3. **Limited Access to Healthcare:**
    - **Challenges in Healthcare Access:** The remote and sparsely populated nature of Turkana County poses challenges in accessing healthcare facilities. Limited availability of healthcare services, including diagnostic tools and antimalarial medications, may result in delayed diagnosis and treatment.
4. **Poverty and Socio-Economic Factors:**
    - **Poor Housing Conditions:** Poverty contributes to substandard housing with inadequate protection against mosquitoes. The lack of proper housing increases the risk of mosquito bites, exposing individuals to malaria transmission.

- **Limited Resources for Prevention:** Economic constraints may hinder the adoption of preventive measures such as the use of insecticide-treated bed nets and indoor residual spraying.

5. **Water Scarcity and Sanitation Issues:**

   - **Waterborne Diseases:** Turkana faces challenges related to water scarcity and inadequate sanitation facilities, leading to the prevalence of waterborne diseases. The coexistence of waterborne diseases with malaria exacerbates health risks in the population.

   - **Open Defecation:** Limited access to proper sanitation facilities contributes to open defecation practices, creating an environment favorable for the breeding of mosquitoes.

6. **Nomadic Lifestyle and Migration:**

   - **Nomadic Communities:** Some communities in Turkana maintain a nomadic lifestyle, frequently moving with their livestock in search of water and pasture. This mobility may disrupt consistent access to healthcare services, including malaria prevention and treatment.

   - **Seasonal Migration:** Seasonal migration patterns of both humans and animals can impact the transmission dynamics of malaria, as individuals may move to areas with different malaria risk profiles.

7. **Limited Educational Opportunities:**

   - **Knowledge Gaps:** Limited access to education can result in knowledge gaps regarding malaria prevention and control. Understanding the importance of early diagnosis, proper treatment, and preventive measures may be compromised in communities with lower educational levels.

8. **Climate Change and Environmental Degradation:**

   - **Impact on Vector Behavior:** Changes in climate patterns and environmental degradation can influence the behavior and distribution of malaria vectors. These factors contribute to the expansion of areas suitable for vector breeding and malaria transmission.

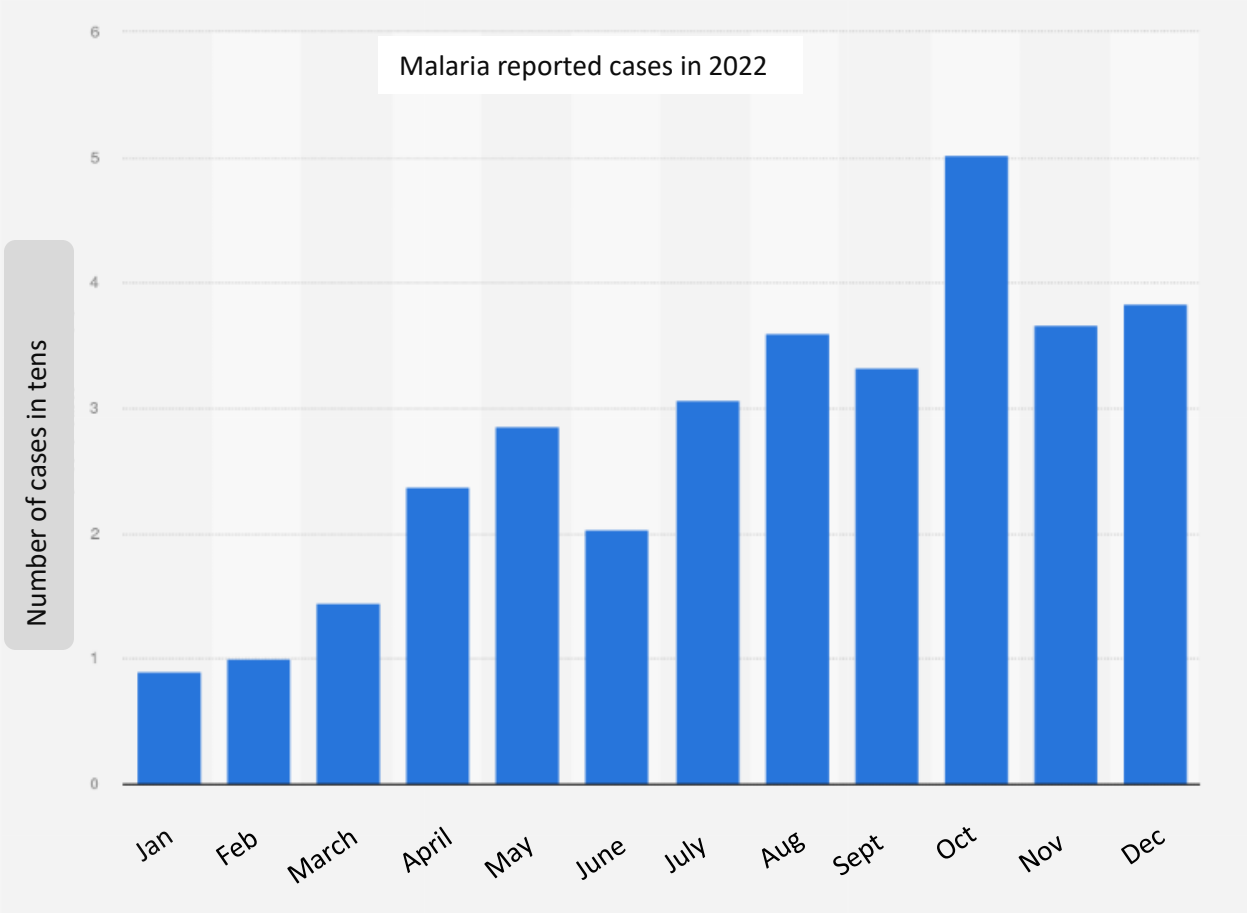


Figure 13: Malaria cases reported in 2022 in Turkana County

Socioeconomic factors influencing malaria

a) Poverty

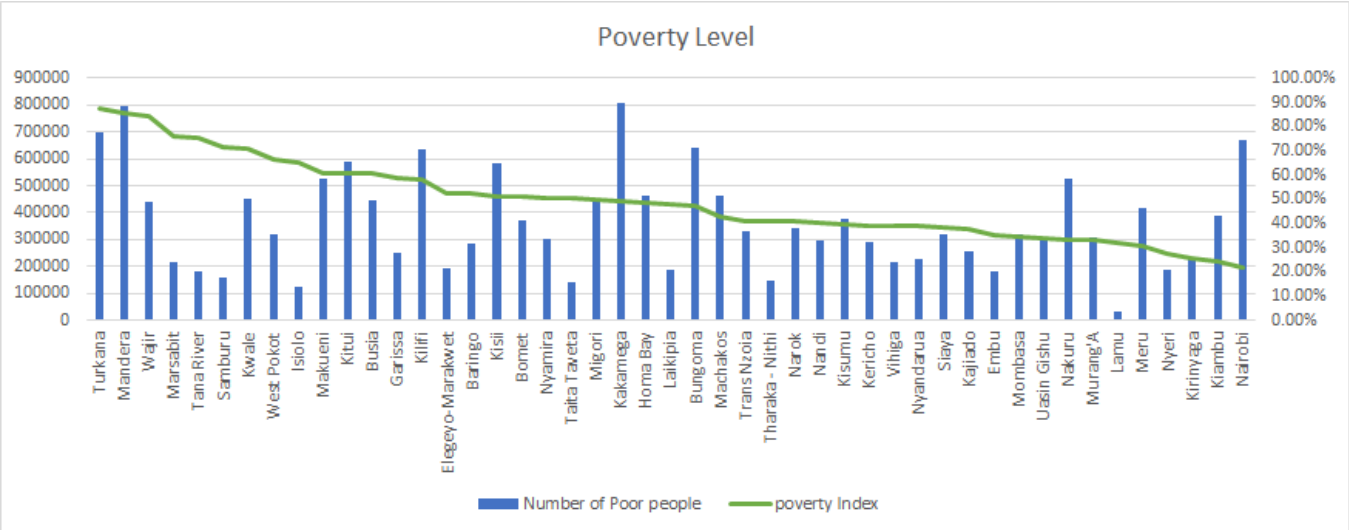


Figure 14: Poverty levels in Kenya

Turkana County is the third county in Kenya with the highest poverty rate in the country. Poverty significantly influences the prevalence and impact of malaria in vulnerable communities. Limited financial resources often translate into inadequate housing conditions, making individuals more susceptible to mosquito bites, the primary vector for malaria transmission.

Impoverished populations may lack access to essential preventive measures, such as insecticide-treated bed nets and proper healthcare services. Additionally, impoverished areas may struggle with insufficient sanitation and drainage systems, creating stagnant water pools that serve as breeding grounds for mosquitoes.

b) Access to health care

Access to healthcare in Turkana, an arid and semi-arid county in northwestern Kenya, is often challenged by geographical remoteness, infrastructure limitations, and a scarcity of resources. These barriers significantly impact the prevention and treatment of malaria, a prevalent health concern in the region.

The vast distances between communities and healthcare facilities, coupled with the nomadic lifestyle of many residents, can impede timely access to medical services. In addition, the shortage of healthcare facilities and trained personnel in Turkana poses a substantial obstacle to effective malaria management.

Limited healthcare infrastructure also affects the availability of diagnostic tools, antimalarial medications, and preventive measures, such as insecticide-treated bed nets.

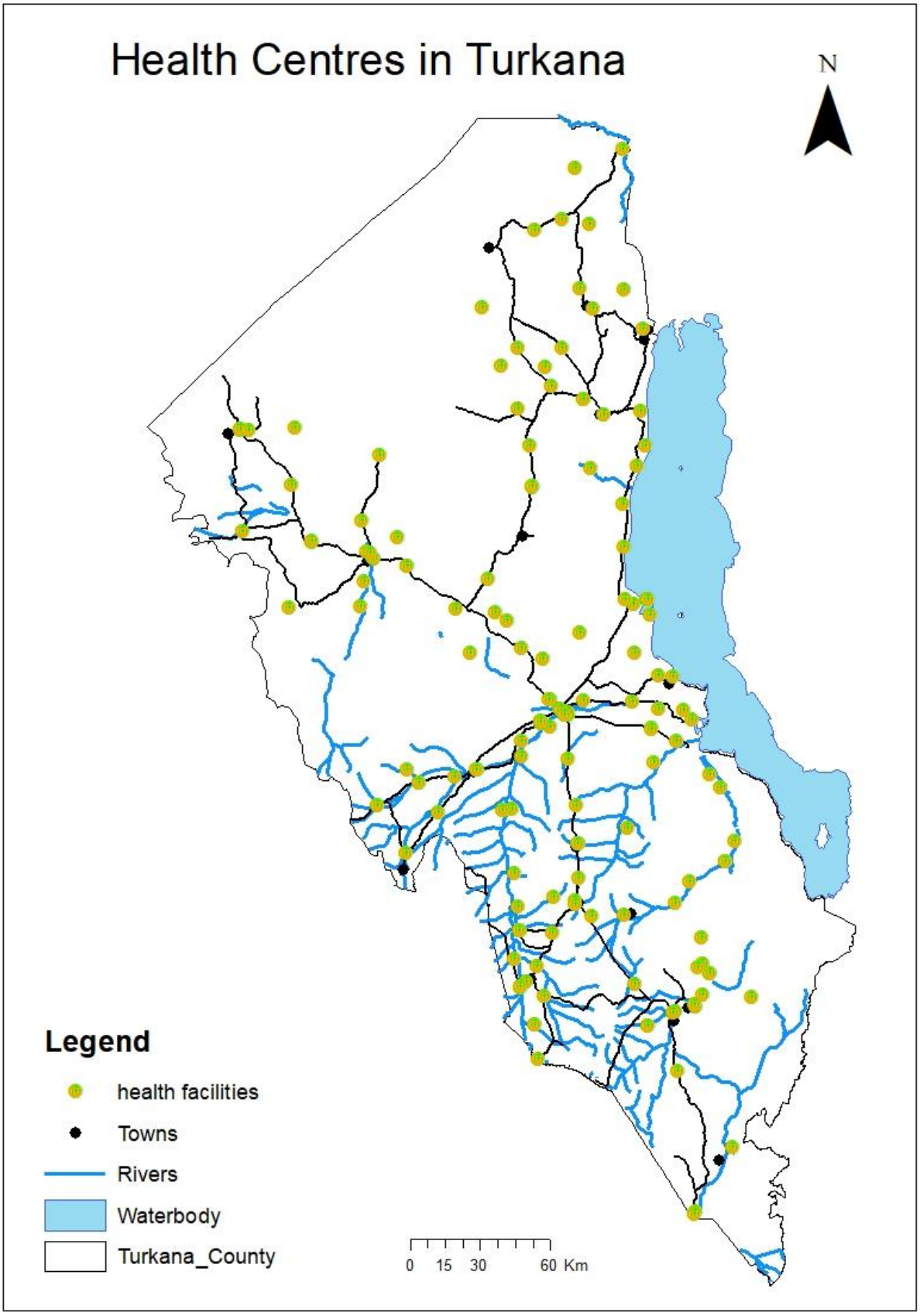


Figure 15: Health care access in Turkana

Emergence of New Malaria Species Anopheles

Researchers from Kenya's Medical Research Institute have detected a new species of mosquito in the East African nation that has shown resistance to locally used insecticides and the potential to transmit malaria throughout the year, unlike traditional malaria-causing mosquitoes.

The mosquito species -- named Anopheles stephensi -- was previously only known to spread malaria in South Asia and parts of the Arabian Peninsula, according to the World Health Organization. However, it has been expanding geographically -- first being detected in Africa in Djibouti in 2012 -- and has since being found in several African nations such as Nigeria, Somalia, Ethiopia and Sudan.

This, however, is the first time the mosquito has been detected in Kenya and its arrival is raising concern among researchers who say malaria transmission may continue all year round, rather than being seasonal due to its ability to "spread very fast to new areas" regardless of climatic and environmental conditions.

The Anopheles stephensi is unique as it thrives in man-made containers and breeding habitats in polluted settings. It can breed in cisterns, jerry cans, tyres, open tanks, sewers, overhead tanks, underground tanks and polluted environments. Furthermore, the mosquito is invasive. The establishment of Anopheles stephensi in urban and peri-urban areas may pose a serious threat for malaria transmission in areas that have been Anopheles and malaria free.

The fact that they are breeding successfully in hot, dry regions like Turkana should cause public health officials to rethink their assumptions about malarial hot spots. Data from hospitals in the area have also shown an uptick in malaria cases outside the usual malaria season.

Factors that favor the breeding grounds of Anopheles stephensi in Turkana County

1. **Environmental Changes:**

Increase in temperature: 2022 saw increase in temperature as the county faced a drought hazard. This favored the breeding condition of Anopheles Stephensi. Tempatures during the day sky rocketed to ove 30 degrees Celsius.

2. **Human Activities:**

- **Presence of Artificial Containers:** such as water storage tanks, barrels, pots, and discarded tires. These containers provide suitable breeding sites, especially in urban settings where water storage and improper waste disposal are common.

- **Poor Drainage:** During flash floods, rainwater can accumulate and create breeding grounds for mosquitoes. Clogged drains and improper water management contribute to the persistence of stagnant water, providing an ideal environment for mosquito larvae.

3. **Vector Competence:**

- **Presence of Stagnant Water:** sites include ponds, puddles, open sewage open drains, and containers that collect rainwater. These breeding sites provide a suitable environment for the mosquito life cycle.

County	Subcounty	Locality village	Habitat type	Larvae presence
Turkana	Turkana Central	Nakwamekwi	River pan (3 sites)	Yes (*An. stephensi*)
Turkana	Turkana Central	St. Monicah	Drainage ditch (2 sites)	Yes
Turkana	Turkana Central	St. Monicah	Cisterns (2 sites)	Yes
Turkana	Turkana Central	Kanamkemer	Cisterns (3 sites)	Yes
Turkana	Turkana Central	Natot	Irrigation canal (1 site)	Yes

Figure 16: Numbers of mosquito larvae to identify Anopheles stephensi mosquitoes

Total *Anopheles* larvae collected	193
Sample size	193
An. stephensi	50

Figure 17: Number of larvae collected

Results

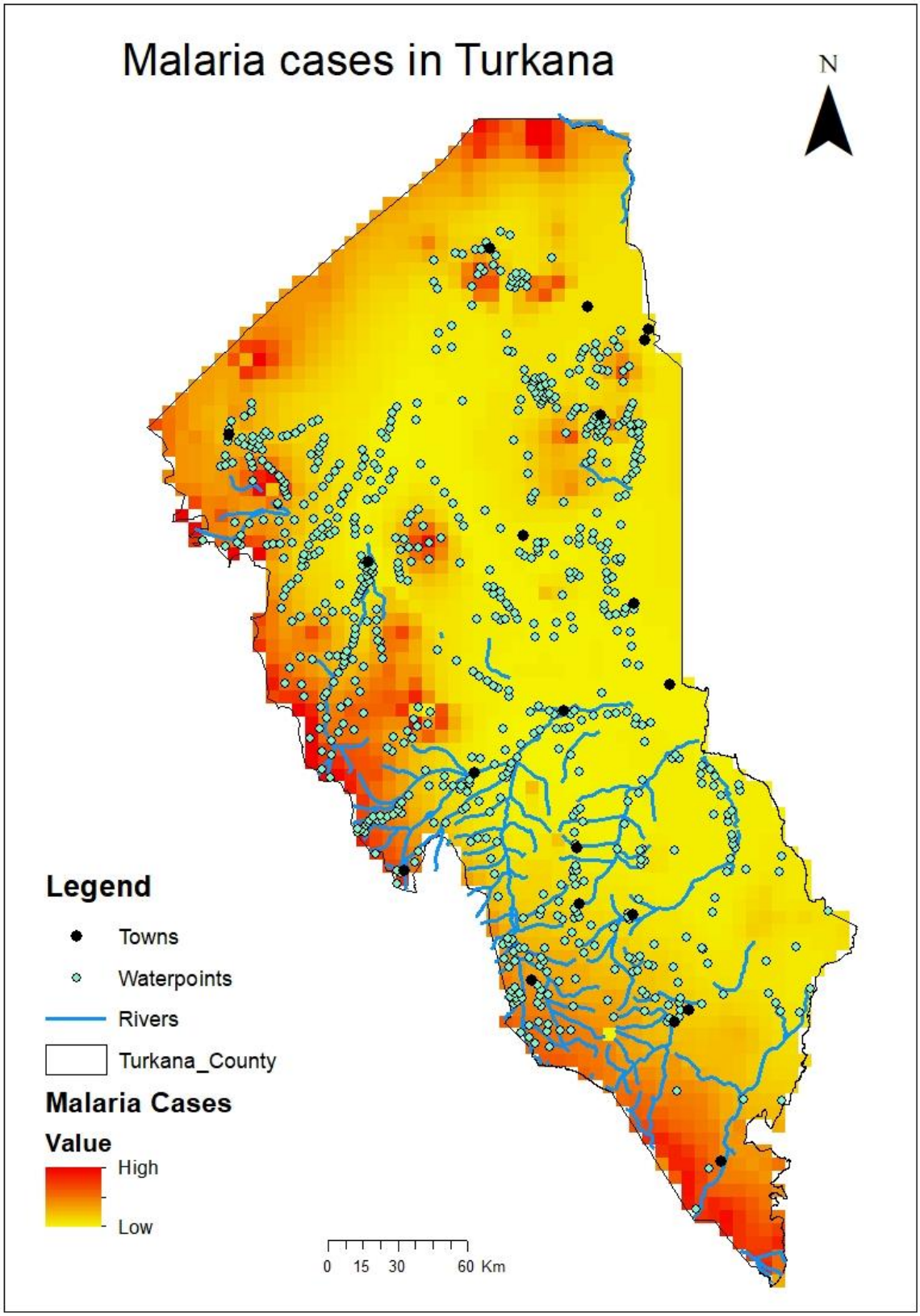


Figure 18: Malaria Cases in Turkana County

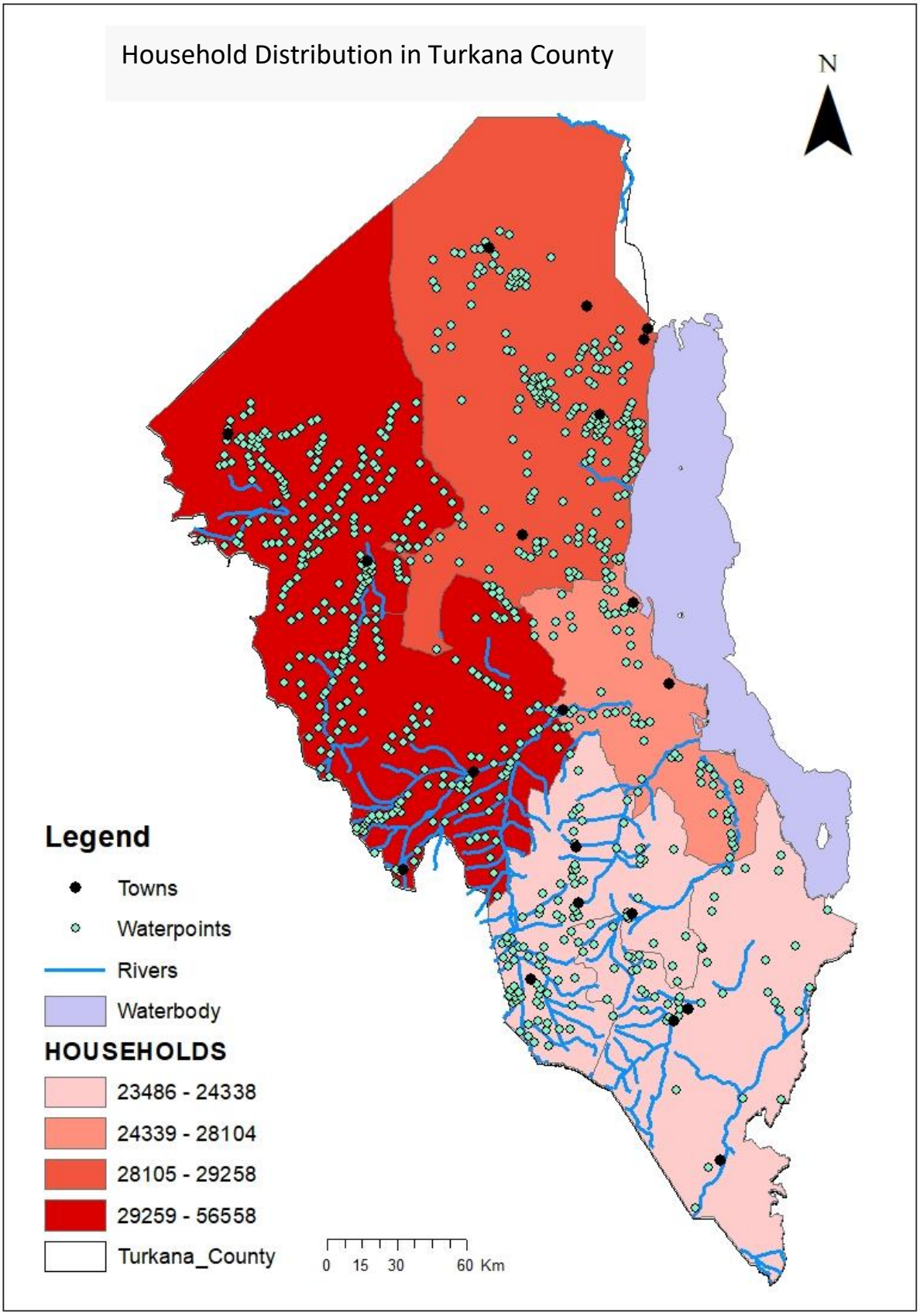


Figure 19: Households distribution in Turkana

Challenges in discovering of Anopheles stephensi in Turkana County

The samples to find the malaria species were collected over a short time frame in a limited number of sites; in Turkana County, only 4 collections in two months at nine sites.

Therefore, the temporal and spatial extent of An. stephensi is still largely unknown and it is likely more widespread than this initial findings would suggest. Furthermore, only larval samples of An. stephensi could be collected, again pointing to gaps in our understanding of its adult behavior, hence the ability to optimize and target adult sampling tools and methods.

Conclusion

For Anopheles stephensi to have been discovered, it means that the climatic and environmental conditions in Kenya more particularly Turkana County were favorable to its breeding conditions. This shows that there is a correlation between climate change, Land and environmental degradation and public health.

If *Anopheles stephensi* were to spread in a city like Nairobi, the consequences would be serious. First, malaria could spread to the inner-city areas. Until now, these areas have had little or no transmission and their populations have not acquired immunity against malaria. Secondly, urban development would no longer be assumed to contribute to malaria elimination.

Urbanization has added to many health problems. But it has tended to “build out” malaria through better housing and gradual pollution of the landscape. Traditional malaria vectors can’t breed in small containers or in water with organic pollution. The new invasive species may mean that the development of new suburbs is building malaria into the landscape.

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