Assessment of the Vulnerability of Residential Areas to Floods in Mabatini Ward in Mwanza City Council, Tanzania

Humphrey C. Matekere[1*] and Christopher M. P. William[2]
[1,2]University of Dar es Salaam, Tanzania
*Corresponding Author: humphreymatekere@gmail.com
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Abstract
Flooding is a growing problem in Mabatini Ward, Mwanza City, where many people live in crowded settlements with poor drainage and weak infrastructure. This study assessed how vulnerable these residential areas are to floods by combining maps, satellite images, and community input. Results show that vegetation has reduced by more than 40% since 2005, while built-up areas have more than doubled, creating more hard surfaces that increase runoff. Analysis of the Mirongo River buffer zone found over 6,400 buildings and about 25,600 residents at risk. Flood maps revealed that water can remain stagnant for several days in low-lying areas, especially where houses are built too close to the river. The findings highlight clear hotspots of risk and show that unplanned urban growth is worsening flood impacts. To reduce vulnerability, the study recommends better drainage systems, stricter land-use planning, replanting vegetation, early warning systems, and stronger community awareness. These measures can help improve resilience and protect lives and property in Mabatini Ward.

Keywords: *Floods, Vulnerability, Residential Areas, Land Use/ Cover Change.*

INTRODUCTION

Floods are among the most frequent and destructive climate-related disasters worldwide, causing loss of life, damage to infrastructure, and economic disruption (Wilbanks et al., 2012). In many developing countries, rapid urbanization, deforestation, and poor drainage systems have intensified these risks (Pradhan et al., 2011). Across Africa, recent flood events have displaced thousands of households and highlighted the urgent need for better preparedness (Feyen et al., 2013).

In Tanzania, several regions including Dar es Salaam, Tabora, Arusha, and Mwanza have experienced severe flooding in recent years (Rojas et al., 2013). Mwanza City, located along Lake Victoria, is particularly vulnerable due to its steep slopes, rocky terrain, and settlements along river valleys (Mauro and Guirong, 2018). The Mirongo River, which flows through the city, frequently overflows during heavy rains, leading to repeated flooding in surrounding communities.

Mabatini Ward, one of the most densely populated areas in Mwanza, faces high exposure to floods because of unplanned settlements, reduced vegetation cover, and encroachment into natural drainage zones (Mauro & Guirong, 2018). These conditions increase stormwater runoff, erosion, and stagnation of floodwaters, threatening lives and property (Macarthur, 2018). Despite recurring floods in Mabatini Ward, there is limited spatial evidence identifying the most vulnerable areas and assets, which makes it difficult for planners and communities to take effective action.

Previous studies conducted in Mabatini have given little attention to the use of geospatial technology in assessing the flood vulnerability of residential areas. This limited utilization of geospatial technology stems from a lack of awareness among researchers and policymakers about its potential advantages.

The study aims to assess land use and land cover changes that influence flood risk in Mabatini Ward, to identify residential areas, assets, and populations located within flood-prone zones, and to generate flood hazard maps using GIS and geomorphic modeling for improved planning and resilience. In line with these objectives, the research seeks to answer three key questions: how land use and land cover have changed in Mabatini Ward between 2005 and 2024, which residential areas and assets are most exposed to flooding along the Mirongo River, and what spatial strategies can be implemented to reduce vulnerability and strengthen community resilience.

METHODOLOGY

Description of the Study Area

Mabatini Ward is one of 12 wards in Nyamagana District, originally part of Mwanza City's 21 wards, 12 in Nyamagana and 9 in Ilemela. In 2015, administrative boundaries expanded to 37 wards, adding 16 new ones. The ward is located in Mwanza Region, northern Tanzania, between latitudes 10°30′ and 3° south. The region spans 25,233 km², with 53.25% covered by Lake Victoria, leaving 11,796 km² of dry land, according to the Regional Commissioner's Office – Mwanza (2013). This geographic context highlights the importance of water resources, land distribution, and administrative planning.

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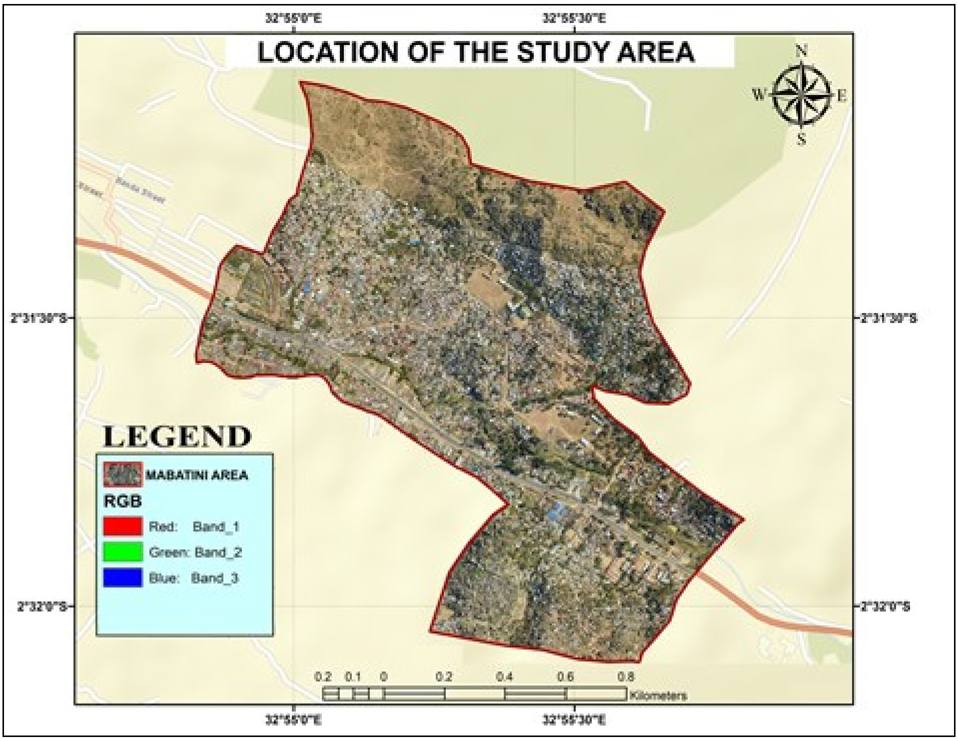
The city features hills, rock formations, and a natural drainage system that is part of the Lake Victoria watershed. These physical features influence flood patterns, erosion risks, and seasonal water flow dynamics across urban and peri-urban zones, while shaping ecological balance, community livelihoods, and environmental resilience. The terrain also creates challenges for infrastructure expansion, disaster preparedness, and climate adaptation, requiring integrated approaches to urban planning and hazard management. These directly determine how floods spread and which areas are most vulnerable.

The study area is bordered by Unguja and Mbugani 'B' Wards to the northwest, Nyashana to the northeast, Buzuruga and Nyakato to the east, Bugarika and Igogo to the west, and Mwananchi to the south. Nyamagana District, part of Mwanza's regional capital, attained city status in 2000, becoming Mwanza City Council. It is well-connected by major roads, residential routes, service roads, and transport links, connecting wards to Buzuruga and the Mara Region. These networks facilitate trade, mobility, and emergency response across diverse urban landscapes, supporting regional economic integration and sustainable development opportunities. Road and transport accessibility also influences emergency evacuation during floods.

Previously, Mabatini Ward was divided into villages, including Mabatini Kaskazini, Kusini, and Nyerere A, B, and C. A 1:7,500-scale map was created to represent the study area, ensuring visibility of details and supporting participatory mapping with the local community. This mapping exercise aids urban planning initiatives for future growth, disaster risk reduction, and sustainable infrastructure development through inclusive, climate-resilient, and data-driven decision-making strategies. It prioritizes equity, safety, adaptive environmental management, and long-term resilience, ensuring planning processes address both immediate risks and future generations' needs.

Figure 1
This map shows the position of Mabatini Ward within Mwanza City. It shows surrounding wards and the Mirongo River, which is central to flood risk in the area. It provides geographic context for the study and helps readers understand the ward's boundaries and terrain features.



Source: URT, 2024)

Data Collection

The study utilized spatial and non-spatial primary and secondary data to analyze environmental patterns and risks. Spatial data included Digital Elevation Models (DEMs), land use and cover maps, soil characteristics, drainage networks, remote sensing imagery, climate variables, settlement distribution, and catchment areas (Mukherjee et al., 2013).

These datasets provided insight into terrain, hydrology, and anthropogenic influences. Non-spatial data complemented the spatial analysis, with qualitative insights from literature and expert opinions, while quantitative climate data came from the Tanzania Meteorological Agency (TMA) and global databases like Open StreetMap (OSM) and the National Bureau of Statistics (NBS).

This combination enabled a strong environmental and socio-economic assessment, improving accuracy, reliability, and relevance. Participatory mapping showed frequently flooded areas. A high-resolution, 15-meter satellite image helped people mark flood-prone zones. To make the image clearer, techniques like contrast stretching, sharpening, and color mixing improved visibility. Other enhancements, including edge detection, histogram equalization, and vegetation indexing, further improved accuracy. These steps increased clarity, supported flood prevention, reduced risks, and guided future planning for community resilience and environmental management.

Data Processing and Analysis

Field observation and ground truthing was done to validate information gathered from participatory mapping (Ojigi et al., 2013). This involved site visits utilizing a mobile Global Positioning System with 5-meter accuracy to verify flooded areas in the city and assess the location at-risk, including (Kursah, 2013). GPS data were overlaid with satellite imagery, to determine flood hazards and spatial distribution (Schowengerdt, 2012).

Plate 1

Community members and researchers engaged in participatory mapping to identify flood-prone areas in Mabatini Ward. The exercise combined local knowledge with GPS data collection to validate hazard zones and improve the accuracy of spatial flood risk assessments.

Source: Field survey, 2019

To identify potential flooding areas factors used in the analysis include DEM, rainfall, drainage systems, settlement patterns, and catchment areas. DEMs were essential for assessing terrain characteristics such as elevation, slope, and drainage features. A series of assessments, including hydrological flood modeling and vulnerability evaluations of buildings based on land use and land cover, were done to determine the risk exposure of residential zones. The Department of Urban Planning and Development outlines that buildings near water sources must maintain a 60-meter distance from riverbanks to mitigate flood risks. A buffering analysis was conducted for the Mirongo River, utilizing geo-processing tools to establish a 60-meter buffer zone.

The analysis started by loading spatial data into ArcGIS, including the Mirongo River polyline and residential buildings layers in polygon features. Before spatial analysis, all layers shared were projected in coordinate system, UTM Zone 36S, to allow for accurate distance-based calculations. ArcGIS uses Euclidean geometry for spatial operations in projected systems, which enables precise measurements in meters rather than degrees, which are unsuitable for distance-based analysis and spatial flood risk assessments.

The 60-meter buffer along the Mirongo River was created. Using the Buffer tool, a 60-meter buffer was generated around the Mirongo River to represent a potential flood-prone zone. The buffer was constructed by expanding a polygon 60 meters outward in all directions from the river's channel. The "dissolve" option was applied to merge overlapping buffer zones, ensuring the output was a continuous, singular polygon. The buffer creation relies on Euclidean buffering, which calculates the radial expansion of each feature from its edge.

$$\text{Buffer}\ (x, y, d) = \text{Region within distance d of point}\ (x, y)$$
$$(\text{x,y}) = (\text{x} - \text{coordinate}, \text{y} - \text{coordinate})\ \text{or}\ (\text{Easting, Northing})$$
$$\text{d} = 60\ \text{m} = \text{Buffer distance provided}$$

Residential structures within the buffer zone were identified using a spatial relationship query which select layer by location. The condition used was "intersect", which identifies features that spatially overlap with the buffer polygon. In estimating building exposure, the exposure level was quantified using the Summary Statistics and Field Calculator tools. If a population attribute (e.g., residents per structure) was available, a sum was calculated to estimate total population at risk. Otherwise, the number of buildings was counted. ArcGIS also allows geometry-based calculations (e.g., area or perimeter) using Calculate Geometry, applying basic geometric formulas depending on the feature type as area of polygons). For buildings only:

The final map was created, and the output layers were styled and laid out using ArcGIS Map Layout View, which includes standard cartographic elements such as legend, scale, and title, displayed in Figure 4, map A. No numerical algorithms are used here, but layout relies on best practices in visual design and cartographic symbology standards.

Boolean Overlay with Flood Susceptibility Indices was performed to enhance the accuracy of the buffer-based flood risk analysis; the 60-meter buffer layer was overlaid with geomorphic flood indices (GFI raster in Figure 4, map B), flood zones from remote sensing, or historical flood records. This step used Raster Calculator or Map Algebra to combine layers and extract intersecting zones.

In case of combining raster and vector data, zonal statistics were used to summarize raster values within the vector buffer zones, improving risk visualization, analytical precision, and flood mitigation planning for better decision-making in vulnerable regions. This analysis was intended to assess the proximity of residential structures to the river, as buildings within this buffer are deemed vulnerable to flooding. Structures located 60 meters or more from the river are considered safe, while those within this range pose a higher risk. The findings indicate that human settlements and constructions encroaching on this buffer heighten susceptibility to flood impacts, increasing damage potential and environmental degradation.

A DEM with a resolution of 30m×30m facilitated the creation of a simulation model to visualize drainage patterns and water runoff during heavy rainfall, processed using Arc Map version 10.3 (Mwanukuzi, 2008). High-resolution satellite imagery from an UAV, acquired from the Ministry of Land, Housing and Human Settlement, illustrated settlement patterns for participatory mapping and base map development.

Soil data from the FAO classified Mwanza Region's soils into three groups: sandy soils, red loams from limestone, and black clay soils, with information linked to textural classes and hydrologic groups. Climatic data, including precipitation and temperature records from 1995 to 2024, collected from the TMA (Mukherjee et al., 2013).

Geomorphic Flood Assessment Model

A Geomorphic Flood Assessment Model was used to simulate flood hazards. Model incorporated four spatial data layers essential for flood hazard simulations: Digital Elevation Model (DEM), filled DEM, flow direction, and flow accumulation. The primary data source is a raster DEM obtained from the United States Geological Survey, which has a spatial resolution of 30 meters. This model employs advanced algorithms to effectively partition landscapes into hydrologic units, facilitating hydrologic modeling and water resource assessment. The first step in geomorphic flood assessment modeling is to preprocess the DEM to ensure it accurately represents surface hydrology.

Natural terrain may contain imperfections or artificial depressions (sinks) that trap flow during hydrologic analysis. These must be removed using a sink-filling algorithm. This prepares the DEM for realistic flow routing in subsequent steps. After filling sinks, the flow direction was calculated. This determines the path water takes from each cell based on the direction of the steepest descent. The D8 algorithm is commonly used, where each cell flows into one of its 8 neighbors. This flow direction raster is essential for computing flow accumulation. With flow direction established, a flow accumulation raster is created.

This measures how many upstream cells drain into each cell. High values indicate areas where water converges, such as streams or valleys, and are key indicators of potential flood zones, influencing flood mitigation and disaster preparedness strategies. Then, Stream Network Extraction was done. The stream network is derived from the flow accumulation raster by setting a threshold. Cells with accumulation values above a certain threshold are considered part of a stream. This raster is used later in calculating HAND and proximity to water. Slope Calculation was performed to identify flat areas more likely to flood versus steep areas less likely to flood. This is typically derived using the elevation gradient in both the x and y directions.

Height Above Nearest Drainage (HAND) was identified as one of the most important indices in geomorphic flood modeling. It calculates the vertical distance from each cell to the nearest stream. Lower HAND values suggest areas closer in elevation to drainage channels and therefore more flood-prone. Before combining terrain indices into the final GFI, each raster is normalized to a common 0–1 scale. This ensures that all variables contribute proportionally regardless of their original units or ranges.

The Geomorphic Flood Index (GFI) was computed by combining the normalized terrain variables into a single composite raster. This is typically done through a weighted sum. The weights can be adjusted depending on the importance of each factor or using data-driven methods. After calculating the GFI raster, a threshold is applied to classify areas as flood-prone or not. Cells with GFI values below a certain threshold are considered flood-susceptible. This final raster was validated using satellite imagery and historical flood maps.

Socio-economic Vulnerability Limitations

This study primarily assessed physical exposure to floods using spatial data (DEM, LULC, building footprints, and buffer analysis). While these methods provide clear evidence of which areas and assets are at risk, socio-economic indicators such as household income, education level, housing quality, access to services, and coping capacity were not systematically integrated into the vulnerability assessment. Community inputs from participatory mapping and focus group discussions provided qualitative insights into residents' experiences, but these were not quantified into socio-economic indices. As a result, the analysis emphasizes where people are exposed rather than how their social and economic conditions may influence resilience or recovery.

The absence of detailed socio-economic data means that vulnerability is represented mainly in spatial terms. This may minimize differences between households for example, poorer families in informal housing may be less able to recover from flood impacts compared to wealthier households in more durable structures

FINDINGS AND DISCUSSION

Land Use – Land Cover Change Detection

Table 1 shows land cover changes between 2005 and 2024, measured in square meters. The classes include vegetation, bare land, roads, settlements, and water bodies. The percentage coverage for each class was calculated using the formula:

$$\text{Percentage Coverage (\%)} = \frac{\textit{Area of Land class}}{\textit{Total Study Area}} * 100\%$$

Vegetation categories include forests, grasslands, shrubs, and other green cover types. Vegetation cover has decreased sharply over time: in 2005 it was 1,217,180 m² (73.07%), dropping to 808,980.9 m² (48.56%) in 2018, and further to 484,494.28 m² (29.08%) in 2024. This decline is linked to urbanization, deforestation, cultivation, land degradation, and conversion for infrastructure projects.

Roads represent transportation networks such as trunk roads, service roads, paved surfaces, and bridges. They covered 58,277.2 m² (3.50%) in 2005, increased to 91,225.5 m² (5.48%) in 2018, but dropped to 48,474.6 m² (2.91%) in 2024. These fluctuations may reflect temporary construction, changes in road plans, or infrastructure upgrades.

Bare land, including exposed soil and rock outcrops, rose from 72,975.9 m² (4.38%) in 2005 to 382,685.6 m² (22.97%) in 2018, then slightly decreased to 352,278.07 m² (21.14%) in 2024. This trend is linked to deforestation, erosion, and land degradation.

Buildings and settlements expanded steadily, from 263,570.6 m² (15.82%) in 2005 to 382,861.7 m² (22.98%) in 2018, reaching 569,926.88 m² (34.21%) in 2024. Growth is driven by urbanization, population increase, and housing demand.

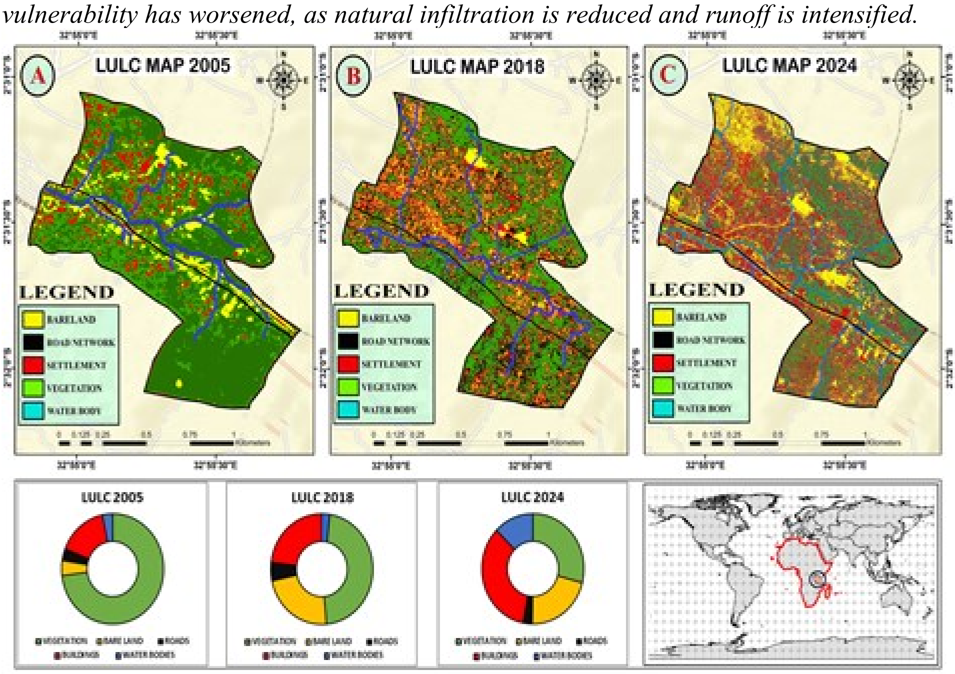
Water bodies covered 53,790.06 m² (3.23%) in 2005, dropped sharply to 40.06 m² (0.002%) in 2018, then rose to 210,691.26 m² (12.65%) in 2024. These fluctuations may reflect climate variability, seasonal rainfall, and inundation events.

Overall, land cover change explains the area's growing flood risk. Vegetated areas reduce flooding, while settlements, roads, and bare land increase runoff and reduce natural infiltration, making Mabatini Ward more vulnerable to floods. These changes highlight the urgent need for effective land management strategies.

Table 1
Land Cover Changes

LULC Type	2005 (m^2 Area)	2018 (m^2 Area)	2024 (m^2 Area)
Vegetation	1,217,180	808,980.9	484,494.28
Bare Land	72,975.9	382,685.6	352,278.07
Roads	58,277.2	91,225.5	48,474.60
Buildings	263,570.6	382,861.7	569,926.88
Water body	53,790.06	40.06	210,691.26
TOTAL	**1,665,793.76**	**1,665,793.76**	**1,665,793.76**

Figure 2
These maps illustrate how vegetation has declined while settlements have expanded over time. Between 2005 and 2024, green areas (vegetation) shrink significantly, while gray and brown areas (buildings and bare land) increase. This change explains why flood vulnerability has worsened, as natural infiltration is reduced and runoff is intensified.



Source: Survey Data, 2024

Flood Vulnerability by Sub-Ward

The GFA model shows that flood coverage varies among sub wards in the study area. Table 2 indicates that Nyerere A sub ward is the most vulnerable, with 31.4% of assets located in the prone zone. Nyerere C has 19.3% of assets in the prone zone, while Mabatini Kusini has 18.3%. Mabatini Kaskazini records 16% of assets in the prone zone, and Nyerere

B has 15%. In total, 11,201 assets are found in flood prone areas, including residential buildings, infrastructure, and essential facilities, indicating significant exposure to potential flood damage.

These findings highlight critical hotspots where flooding can severely affect households, disrupt services, and cause economic losses across the sub wards, making urgent flood management and mitigation interventions necessary to protect both people, property, and community livelihoods effectively.

Table 2

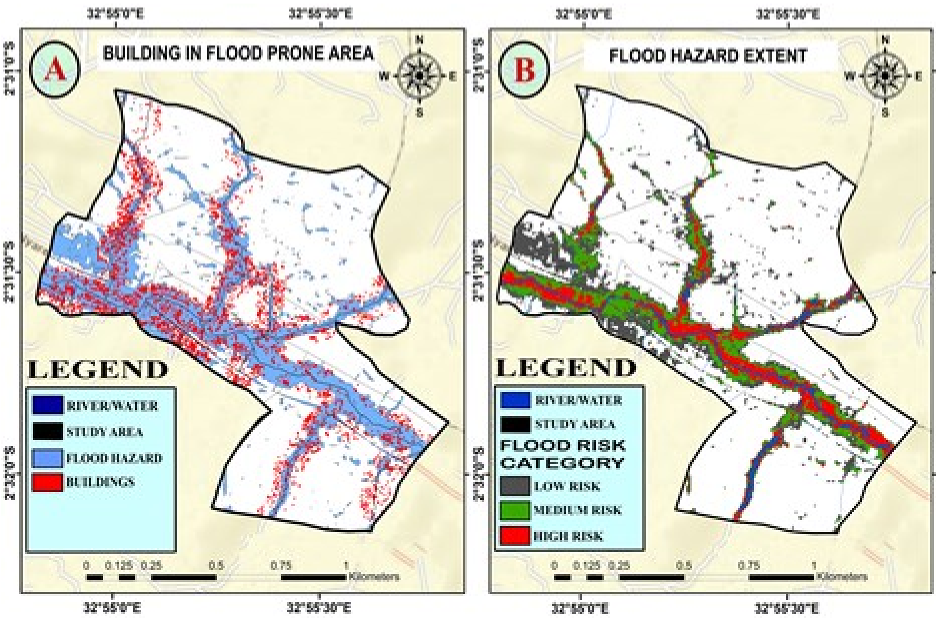
Number of Assets in Flood Prone Area

SUB-Ward	Assets	Percentage	Area (m^2)
Mabatini Kusini	1851	16 %	6520
Mabatini Kaskazini	2048	18.3 %	7338
Nyerere - A	3516	31.4 %	12,822.8
Nyerere - B	1705	15 %	5801
Nyerere - C	2161	19.3 %	7467
TOTAL	**11,201**	**100**	**39,950**

The figure 3 shows a map to illustrate flood-prone zones across the study area. QGIS analysis of the 60-meter buffer revealed a 1,178,883.3 m² area containing 6,477 buildings in the most vulnerable zone, posing a threat to approximately 25,600 residents near the river path. The most affected buildings were informal establishments close to the Mirongo River, requiring urgent mitigation measures and community-driven resilience strategies such as improved drainage systems, land-use planning, and early warning mechanisms.

Figure 3

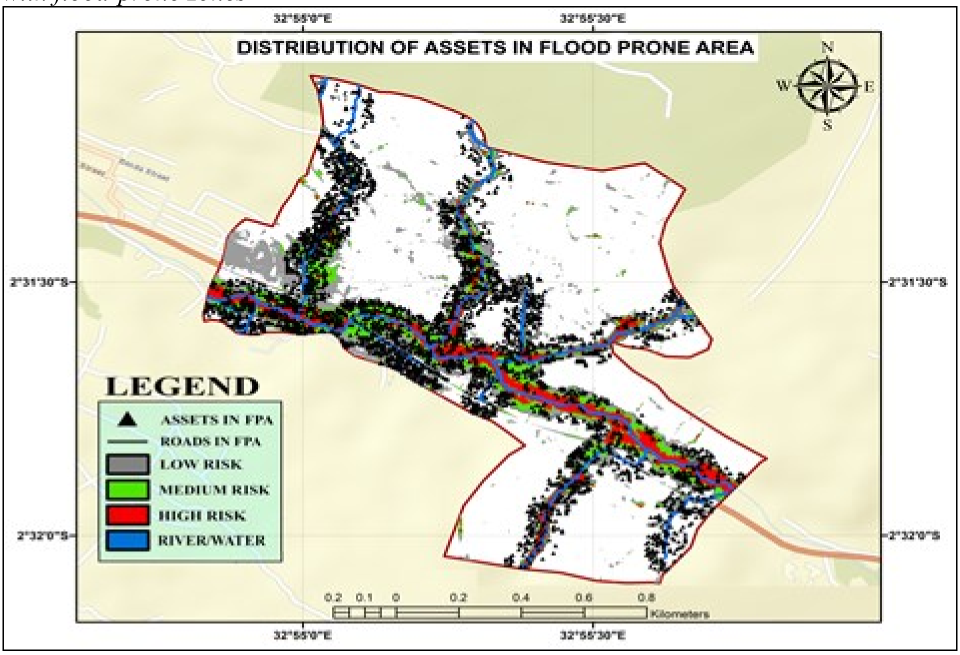
This map shows buildings located in high, medium, and low flood-risk zones along the Mirongo River. Red areas represent houses at highest risk, where floodwater can stagnate for more than five days. Green and gray areas show medium and lower risk zones. The figure emphasizes how unplanned settlements within 20–40 m of the river buffer is most exposed



Source: Survey Data, 2024

Residential areas and infrastructure, including roads, are also located in flood-prone zones. The study area contains 46 roads with a total length of 9,177.7 meters. Of these, 43 roads, equal to 93% of the network, fall within flood-prone areas, with a combined length of 4,315.6 meters. The average road length is 100.4 meters, ranging from a minimum of 1.7 meters to a maximum of 447.5 meters. This high presence of roads within flood-prone zones indicates that transportation and mobility are at risk during floods, which could disrupt access to services and impede emergency response, especially during heavy rainfall. The findings highlight the need for improved urban planning and flood mitigation measures, as most roads are exposed due to settlement expansion into high-risk areas.

Figure 4
This map shows the location of assets exposed to flooding across Mabatini. Sub-wards such as Nyerere A, Mabatini Kusini, and Nyerere C have the highest concentration of vulnerable buildings and infrastructure. The shaded buffer along the Mirongo River highlights areas most at risk, where informal settlements and essential services overlap with flood-prone zones



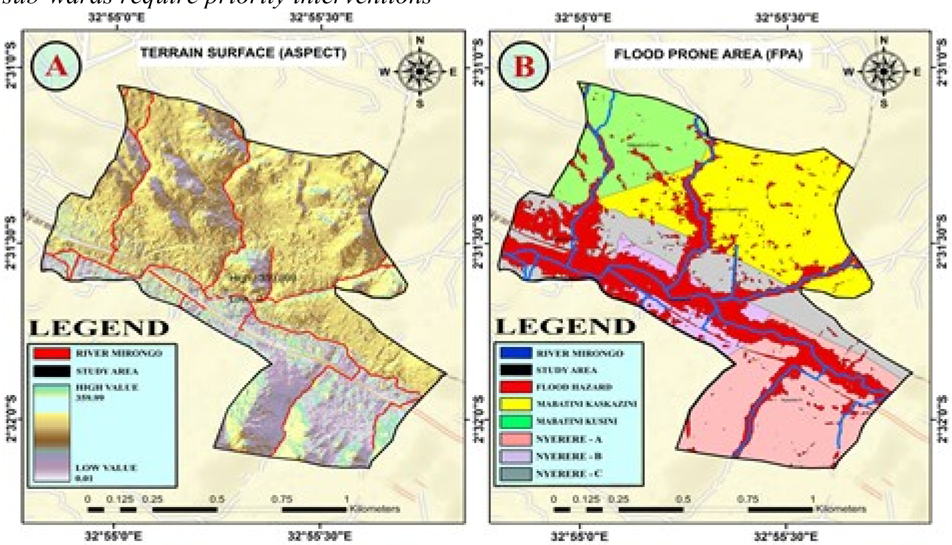
Source: Survey Data, 2024

Assets were categorized according to the area they covered. Those with less than 5 m² accounted for 49,163 items, covering 57,145 m² with an average area of 1.2 m². These included motor vehicles temporarily found in the study area and are highly susceptible to flood damage due to their limited resilience. Assets between 5 m² and 16 m² numbered 2,318, covering 19,981.5 m², with minimum and maximum areas of 5 m² and 15.9 m² respectively.

Water supply networks were also identified among vulnerable assets. A total of 41 networks with a combined length of 17,178.8 meters were recorded, with an average length of 418.9 meters. Of these, 33 networks (80.5%) are located in flood-prone zones, covering 7,894.6 meters. The minimum and maximum lengths were 0.9 meters and 1,600.7 meters respectively. These networks are critical for urban functionality, and their disruption during floods could lead to water shortages, sanitation crises, health risks, and significant disruption to daily activities and essential community services. Other assets found in flood-risk zones include domestic animals, small businesses such as machingas, market commodities, bridges, and public service buildings. Schools, hospitals, offices, factories, and storage units are also at risk, alongside electricity and communication lines. The presence of these diverse and essential assets underscores the need for integrated flood management plans that prioritize human safety, economic resilience, and long-term sustainability.

The study reveals sub wards with varying flood coverage levels and extents. Nyerere 'A' sub ward has the highest flood coverage, covering 221 km2, followed by Mabatini Kaskazini with coverage of 138 km2, Mabatini Kusini with coverage 21 km2, and Nyerere 'B' sub ward with about 17 km2. The study suggests that residents near the river are at higher risk due to human activities as soil erosion, solid wastes deposition in river channel and gentle slopes.

Figure 5
This figure compares terrain surface (Map A) with modeled flood-prone zones (Map B). Darker shading indicates higher flood hazard. Nyerere A sub-ward shows the largest flood area, confirming it as a hotspot of vulnerability. The map helps identify which sub-wards require priority interventions



Source: Survey Data, 2024

Variations in Rainfall and Temperature

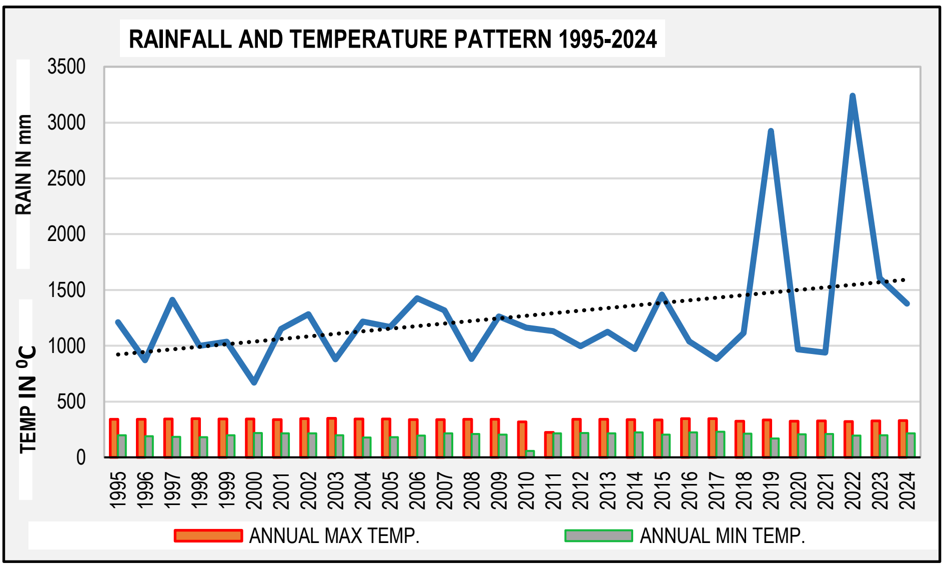
The study area experienced varied rainfall, with three peaks from 1997 to 2015, indicating a fluctuating rainfall pattern. Temperature trends from

1995-2024 were determined using Time Series analysis and the Pearson correlation test, with the lowest average minimum temperature of 4.7°C in 2010 and the highest temperature of 29.10°C in 2003, providing insights into global warming occurrence.

Weather forecasting helps minimize flooding impacts by predicting storms, phenomena, and extreme precipitation events, improving disaster preparedness. The Masika rainfall season in the region is a major concern, with a slight increase in annual precipitation. Flood properties are influenced by precipitation characteristics, including amount, intensity, duration, and spatial distribution, and most research is conducted in small catchments in hyper-arid or high rainfall Mediterranean climates.

Results from statistical tests show no significant correlation between rainfall and average maximum temperature, implying each vulnerability factor plays an independent role in influencing vulnerability in the area. Results show temporal patterns intensify with temperature increases, leading to storms and flooding. Future planning should consider rainfall variability and increases in rainfall, as weather changes are key factors in floods.

Figure 6
Temperature and rainfall trends of study area from 1995 to 2024. The blue line for rainfall and the bars indicate temperature.



Source: Fieldwork, 2024

CONCLUSION AND RECOMMENDATION

The findings of this study emphasize the severe vulnerability of residential areas in Mabatini Ward to flooding, primarily caused by poor drainage infrastructure, rapid urbanization, and environmental degradation. The study identified Nyerere A, Nyerere C, and Mabatini Kusini as the most flood-prone sub-wards, with 31.4%, 19.3%, and 18.3% of assets located in flood-prone areas, respectively.

These hotspots are concentrated along the Mirongo River, where informal settlements and high-density residential buildings encroach within the critical 60-meter buffer zone. The exposure of essential infrastructure, including roads and water supply networks, highlights significant vulnerability to flooding, which can disrupt household livelihoods, urban services, and emergency response. Informal settlements in these zones, encompassing over 738 buildings and approximately 3,468 households, are particularly susceptible, facing potential economic losses, displacement, and disruption of essential services.

Land use and land cover analysis indicates that vegetation cover has decreased by over 40% between 2005 and 2024, while built-up areas have more than doubled. This expansion of impervious surfaces has increased surface runoff and reduced natural infiltration, exacerbating flood impacts. The high density of roads, settlements, and essential services within flood-prone areas reflects gaps in urban planning and weak enforcement of land-use regulations.

To reduce flood vulnerability in Mabatini Ward, interventions should prioritize the most affected sub-wards. Nyerere A, being the most flood-prone area, requires strict enforcement of the 60-meter buffer zone along the Mirongo River. Strategic relocation of households and infrastructure in high-risk zones, supported by incentives, can significantly reduce exposure. Urban planning frameworks should integrate flood-resilient housing designs to protect residents and ensure that future settlements comply with land-use regulations.

Medium-risk sub-wards, including Mabatini Kusini and Nyerere C, require targeted infrastructure improvements. Upgrading drainage systems, constructing retention ponds, and introducing permeable surfaces will help manage runoff and reduce flood impacts. Complementary measures such as early warning systems and community education campaigns will enhance preparedness and enable residents to respond effectively to seasonal flooding events.

Critical infrastructure, including roads and water supply networks, must be retrofitted or relocated using flood-resilient designs, as 93% of roads and 80.5% of water networks fall within flood-prone areas. Strong coordination between urban planning, transport, and water authorities is essential to minimize disruptions during floods and maintain essential urban services. Environmental management strategies, including reforestation, afforestation, and soil conservation initiatives, should also be prioritized to reduce surface runoff, improve water absorption, and mitigate long-term flood risks.

Community participation and integration of GIS-based flood modeling are essential for sustainable flood management. Residents should be actively involved in participatory mapping, awareness programs, and early warning system development to strengthen local governance and compliance with planning regulations. Investments in flood-resistant housing, improved waste management, and relocation incentives will protect vulnerable populations, while the use of GIS and real-time monitoring tools will support data-driven decision-making and long-term urban resilience in Mabatini Ward.

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