UGANDA

Climate Hazard Assessment – Kiryandongo District

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Climate Hazards in Uganda's Refugee-Hosting Districts.

INTRODUCTION

Uganda hosts one of the largest refugee populations in Africa,[1] many of whom live in climate sensitive landscapes highly vulnerable to the impacts of climate change due to its reliance on rain-fed agriculture, limited adaptive capacity, and high exposure to extreme weather events such as floods, droughts, and prolonged dry spells.[2] Over recent decades, the country has experienced more frequent and intense climate hazards, undermining livelihoods, food security, health, and infrastructure.[3,4] Uganda's climate is characterized by a bimodal rainfall pattern; however, this pattern has become increasingly unpredictable, with delayed onset and erratic distribution of rainfall that disrupts agricultural cycles.[5]

Key National Signals

- Temperatures have risen by ~1.0 –1.5°C over the last five decades, increasing heat stress and evapotranspiration.
- More erratic rainfall: delayed onset, mid-season dry spells, intense rainfall events
- Prolonged dry spells and flooding now co-exist as dominant hazards, disrupting agriculture, water access, transport, and shelter

Climate hazards vary across the country, with distinct patterns between the Northern/West Nile and Southwestern regions, highlighting the need for localized analysis. Although both regions are projected to become warmer and wetter by mid-century, the impacts will differ significantly due to variations in baseline conditions, terrain, and livelihood systems.

In the Northern/West Nile region including Yumbe, Koboko, Adjumani, Madi Okollo, Terego, Obongi, and Lamwo, average temperatures are projected to rise from about 25°C to 30°C by mid-century, while annual rainfall increases from roughly 1,138 mm to 1,587 mm. Despite higher rainfall, increased temperatures will accelerate evapotranspiration, leading to greater soil moisture loss and prolonged dry periods during key agricultural seasons. According to the Multi-Sectoral Needs Assessment (MSNA) conducted by **IMPACT Initiatives** in 2024, long dry spells and heavy rains are the hazard types most frequently reported across West Nile and Southwestern regions. With accelerating climate change, they will remain dominant hazards, alongside a growing risk of flash flooding in low-lying and poorly drained areas.[6]

Hazard Type	West Nile	Adjumani	Terego	Koboko	Lamwo	Madi Okollo	Obongi	Yumbe
Drought/Prolonged dry spell	x	31%	39%	40%	46%	31%	36%	46%
Heavy Rains	x	38%	40%	42%	24%	33%	35%	38%
Extreme Temp. Events	x	19%	13%	12%	18%	26%	13%	7%
Flood	x	13%	8%	6%	12%	10%	15%	9%

Table 1: Climate hazards reported in the MSNA, 2024, Northern/West Nile region

In Southwestern Uganda districts, Isingiro, Kamwenge, Kyegegwa, Kiryandongo, and Kikuube, historical temperatures average about **20.3°C** but are projected to rise to around **26°C** by mid-century, marking significant warming. Annual rainfall is also expected to increase from about **842 mm** to roughly **1,372 mm**.

Hazard Type	Southwest	Kiryandongo	Isingiro	Kamwenge	Kikuube	Kyegegwa
Drought/Prolonged dry spell	x	49%	74%	45%	48%	58%
Heavy Rains	x	30%	17%	28%	25%	25%
Extreme Temp. Events	x	16%	6%	23%	18%	13%
Flood	x	6%	3%	4%	9%	3%

Table 2: Climate hazards reported in the MSNA, 2024, Southwestern region

Across both regions, warmer and wetter conditions do not reduce climate risk. Instead, they increase overlapping hazards, with long dry spells, floods, and heat stress occurring in the same districts and seasons. These pressures are especially acute in refugee-hosting areas where land, water, and services are already limited. District-level Climate Hazard Assessment translates national and regional climate trends into local evidence, highlighting key hazards, and exposures to support targeted planning and resilience for host and refugee communities.

Climate Hazard Assessment – Kiryandongo District

CONTEXT & RATIONALE

Kiryandongo District is in Western Uganda's Bunyoro Sub-region and bordered by Nwoya, Oyam, Apac, and Masindi Districts. Its headquarters in Kiryandongo Town lie about 225 km northwest of Kampala. The district is characterised by a bimodal rainfall pattern with two rainy seasons, with the highest rainfall normally received in March - May and August – November.[7] The district faces climate challenges, such as unpredictable rainfall, mid-season dry spells, and intense rains like other districts in Uganda, which disrupt planting, reduce crop yields, and affect pasture.[8] Vulnerability to seasonal drought and flooding, combined with rising temperatures, exacerbates soil moisture deficits and increases the risk of food insecurity and water stress for rural and refugee communities.

Climate projections under the Moderate Socio-economic Path (SSP2-4.5 scenario), which represents a middle of the road development trajectory with moderate emissions and limited climate mitigation, suggest that Kiryandongo will become warmer and moderately wetter by mid-century. Mean annual temperatures are projected to rise from **23°C to 25.7°C**, while annual rainfall is expected to increase from **1,209 mm to about 1,372 mm**.[1] Despite this increase in rainfall, intensifying heat stress is expected to pose greater risks to rural households and displaced populations. [9]

Kiryandongo District hosts over **165,000 refugees,** living in Kiryandongo Refugee Settlement, primarily from the neighbouring conflict-affected countries Sudan and South Sudan.[10] Although Kiryandongo District primarily hosts refugees within the Kiryandongo Refugee Settlement, located in Bweyale Sub-county, there is evidence of increasing interaction between refugees and host communities in nearby urban and peri-urban areas. Bweyale Town has evolved into a busy commercial centre serving both refugees and nationals, with shared markets and services.[11]

This analysis therefore seeks to generate evidence-based insights into historical and projected climate trends to inform climate-resilient humanitarian and development programming in Kiryandongo District.

The district-level analysis provides a comprehensive assessment of hazard susceptibility, exposure patterns, and future climate hazards, equipping government authorities and humanitarian and development partners with the evidence needed to implement targeted interventions, strengthen disaster preparedness, and enhance resilience in Uganda's refugee-hosting districts.

Key Messages

- Kiryandongo District receives **~1,209 mm** of annual rainfall, projected to rise to **~1,372 mm by mid-century (SSP2-4.5)**. However, increased variability, longer dry spells, and higher evapotranspiration may heighten water stress, especially in Mutunda Sub-county due to reliance on rain-fed agriculture and population pressure.
- **Temperatures are projected to increase by 2.4 -2.6°C**, particularly during the warmest month and driest quarters. This will likely increase the frequency of very hot days, heat stress and seasonal drought risk affecting crop productivity, livestock health and water availability.
- Seasonal drought remains a major hazard, with the Standard Precipitation Index (SPI) and Vegetation Condition Index (VCI) indicating moderate to severe dryness. High-risk areas like **Ranch 1, Ranch 37, Bweyale, and Mutunda** Sub-counties face vegetation stress, reduced yields, and limited pasture and water.
- Flooding is recurrent in low-lying river valleys and floodplains, especially along the Victoria Nile and tributaries. Affected areas include **Mutunda, Bweyale Town Council, Masindi Port, and Ranch 1 and 37**, impacting farms, homes, and infrastructure, and increasing vulnerability.

[1] SSP2-4.5 refers to a *moderate climate change scenario* that combines the "Middle-of-the-Road" Shared Socio-economic Pathway (SSP2) with a radiative forcing level of 4.5 W/m² by 2100. It assumes continued socio-economic development along current trends, moderate population growth, and limited but ongoing climate mitigation, resulting in continued warming and increasing climate variability.

Location and Topography

Kiryandongo District is in the Bunyoro Sub region of Western Uganda. It borders Nwoya District to the north, Oyam District to the northeast, Apac District to the east, and Masindi District to the south and west. In Uganda, Kiryandongo lies within the *Southwestern Rangelands Agro Ecological Zone*. This area is known for its abundant natural resources, favourable geology, and strong agricultural potential, including forestry, crop farming, and livestock keeping. The district's elevation ranges from 710 to 1,319 metres above sea level. This contributes to a moderate climate with well distributed rainfall (*see Map 1).*

The terrain is gently undulating with low hills and broad valleys. This influences settlement, land use, and drainage patterns. Most settlements and farming activities are found on well drained slopes and plains. Lower areas, especially around the Kiryandongo Refugee Settlement and along rivers such as the Victoria Nile, are prone to seasonal flooding and waterlogging. These areas shape water flow and can limit infrastructure development.

Fertile soils, varied terrain, and available water support both crop and livestock production. This highlights the need for sustainable land and resource management.

Demographics and Population Distribution

According to the 2024 National Population and Housing Census, Kiryandongo District has a population of over **364,000** people, making it one of the most densely populated rural districts in Uganda.[12] The district's population is ethnically diverse, with the **Banyoro** as the main indigenous group alongside migrant communities from other parts of Uganda. Christianity is the predominant religion, with Roman Catholic and Anglican denominations being the most widespread, while Islam and other faiths are also practiced. The district also has a predominantly young population, with more than half under the age of 18, leading to high dependency ratios and growing demand for social services, such as education and healthcare.[13]A significant portion of the district's population comprises refugees, mainly from South Sudan and neighbouring countries, hosted in the Kiryandongo Refugee Settlement, which was originally established in 1990 and later re-opened in 2014 to accommodate new arrivals. As a receiving settlement, Kiryandongo continues to accommodate new arrivals. By December 2025, the refugee population had surpassed 100,000, reflecting

Map 1: Map showing the Location and Elevation of Kiryandongo District

ongoing influxes driven by regional conflicts and persistent humanitarian needs. The presence of refugees has a considerable influence on demographic patterns, population density, and the demand for basic services across the district. Refugees constitute roughly 15–20 % of Kiryandongo District's population, significantly influencing demographic patterns, population density, and the demand for basic services.[14]

Livelihoods

In Kiryandongo District, livelihoods are predominantly based on subsistence agriculture, with clear geographic variation defined by livelihood zones. Large parts of **Mutunda Sub-county, Bweyale Town Council, Kiryandongo Town Council and Kiryandongo Refugee Settlement fall within the** *Karuma Masindi Oyam Tobacco Maize–Cassava Zone*, where both refugee and host communities rely mainly on maize and cassava cultivated on small plots. Further south, Kigumba Town Council and Masindi Port lie within the *Bwijanga Pakanyi Sugarcane Maize Cassava Zone*, where staple crop farming dominates, while a narrow riverbank zone around Masindi Port supports fishing as a supplementary livelihood.

These livelihoods face significant threats from climatic and environmental stress. Although parts of the district normally receive moderate rainfall (about 151–170 mm annually), the entire district is currently experiencing severe seasonal drought conditions, with most sub-counties classified as extremely dry. This seasonal drought is stressing rain-fed crops, reducing soil moisture, and limiting pasture and water availability for livestock. Areas such as Masindi Port, which already receive lower rainfall, are particularly vulnerable, while refugee settlements face compounded risks due to small land sizes, continuous cultivation, and declining soil fertility. Poor road infrastructure further constrains market access, and environmental degradation including soil erosion, deforestation, and water pollution undermines long-term livelihood sustainability.

Agricultural support efforts in refugee-hosting areas provide households with small land plots, seeds, tools, and basic training on staple crops like maize and cassava. Programs promote drought-tolerant crops, soil and water conservation, and kitchen gardening to boost food security and nutrition. However, limited land, ongoing seasonal drought, and environmental challenges still restrict agricultural productivity in Kiryandongo District.

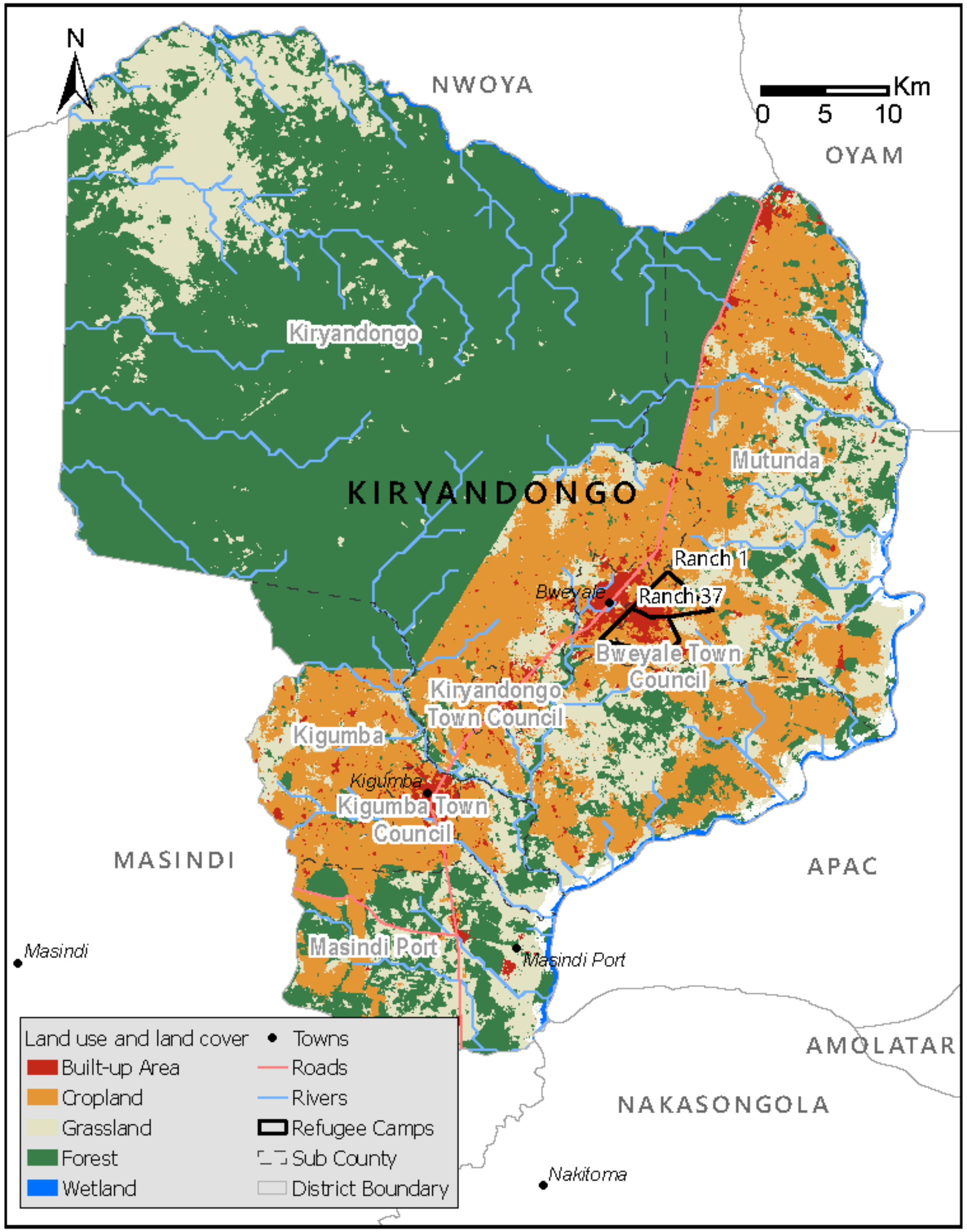
Map 2: Map showing Livelihood Zones in Kiryandongo District

Environment, Land Use and Land Cover

Kiryandongo District, in central northern Uganda, relies on natural systems for rural livelihoods. Forests, grasslands, wetlands, croplands, and rivers support water supply, livestock, farming, and energy needs. The west and north are dominated by forests and grasslands, the central and south by cropland and settlements, and the east by river valley wetlands. These ecosystems face pressure from deforestation, farming, settlement expansion, and refugee settlements, causing soil degradation, water scarcity, and pollution. The population grew from **266,000 in 2014 to 365,000 in 2024**, increasing demand for fuelwood, construction materials, and farmland.[15]

As shown in *Map 3*, Kiryandongo District is predominantly **forested (53%),** providing fuelwood, timber, construction poles, soil fertility, and erosion control, while supporting livelihoods such as timber harvesting, non-timber forest product collection, and livestock fodder. **Cropland (23%)** comes next, crucial for subsistence farming of crops such as maize, cassava, beans, and ground nuts, which form the backbone of household food security and income generation. **Grasslands (20%)** support livestock grazing, seasonal cultivation, and forage production. **Built-up areas (2%)** include towns, trading centres, and refugee settlements that host critical infrastructure, such as schools, health centres, and roads. Finally, **wetlands (2%),** mainly along rivers and low-lying valleys, provide water supply, livestock watering, dry-season farming, and brick making, while acting as ecological buffers, although they are increasingly threatened by encroachment and pollution.

Sub-county and settlement patterns reflect these distributions: Kiryandongo Town Council is mostly made up of cropland with minor forest and built-up areas; Bweyale Town Council has extensive built-up zones with surrounding cropland and hosts Ranch 1 and Ranch 37 refugee settlements; Kigumba Town Council is mainly cropland with some southwestern forest; Mutunda Sub-county is primarily cropland interspersed with grassland; and Masindi Port Sub-county features a mix of forest, cropland, and wetlands along rivers. Overall, Kiryandongo District's **land use is dominated by forests, followed by croplands, grasslands, built-up areas, and wetlands**, reflecting both ecological patterns and human pressures, particularly from population growth and refugee settlements.



Map 3: Map showing Land Use and Land Cover in Kiryandongo District. Source: ESRI land cover map.

CLIMATE CONTEXT

This section presents an analysis of Kiryandongo District's climate using key indicators. Rainfall and temperatures are examined from both historical records and future climate projections to understand long-term trends and emerging hazards. The aim is to provide a clear picture of how climate patterns have evolved over time and how they are expected to change in the coming decades, informing both vulnerability profiling and resilience planning.

Rainfall

Kiryandongo District experiences a bimodal rainfall pattern, characterized by two main rainy seasons occurring in March–April and September–October, as shown by the long-term average (1981–2024). These peaks are separated by relatively drier periods, particularly in **January–February** and **June–July**, which represent the main dry spells. This seasonal pattern strongly influences agricultural calendars, water availability, and livelihood activities across the district *(see Figure 1)*. The rainfall observations for 2022–2024 show marked interannual variability in both the timing and amount of rainfall compared to the long-term average for example.

- **2022:** Rainfall was generally below the long-term average across most months, with pronounced deficits during **June and July,** indicating a weakened mid-year rainy period. Rainfall during **March–April** was slightly below the historical peak, while October and December recorded above-average rainfall. Overall, **2022 was a relatively dry year**, increasing moisture stress during key planting and growing periods.
- **2023:** Rainfall patterns were mixed, fluctuating around the long-term average. Above-average rainfall occurred in **March, June, and October**, while **January, February, and July** were below average. **April and September** were near the historical mean, indicating partial seasonal recovery despite continued dry spells.
- **2024:** Rainfall in 2024 was highly variable, with below-average totals in January, February, and June, and above-average rainfall **in April, August, and November. September and October** were **near the long-term average**, reflecting the second rainy season. This variability indicates increasing unpredictability in rainfall timing, affecting agricultural planning.

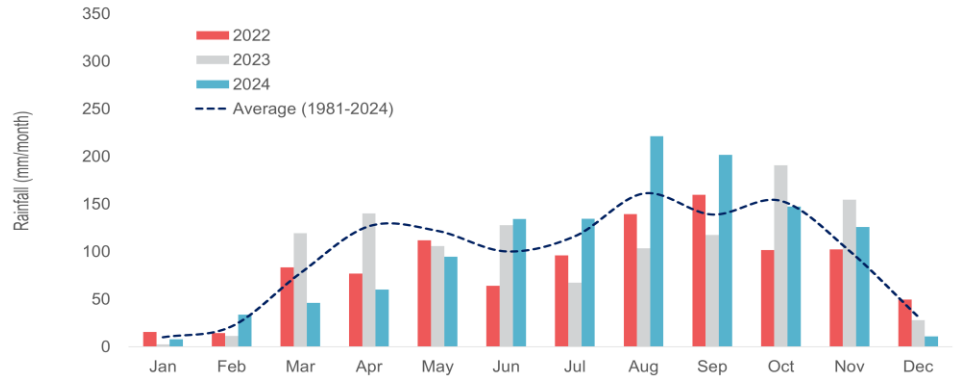


Figure 1: Graph showing Average Annual Rainfall (2022-2024) of Kiryandongo District.

These rainfall fluctuations are influenced by climate variability phenomena, such as the El Niño–Southern Oscillation (ENSO), which affects the onset, duration, and intensity of seasonal rains. ENSO events typically occur on an irregular cycle of 2–7 years and can persist for 9–12 months. In recent decades, increased variability in ENSO timing and intensity has contributed to less predictable rainfall patterns across the region. As a result, Kiryandongo District is increasingly vulnerable to both seasonal droughts and flooding. Prolonged dry spells, particularly during the **December–February period**, lead to water scarcity, crop stress, and pasture depletion, while intense rainfall during the main peak seasons of **March–April and September–October** can trigger localized flooding, crop damage, and disruption of transport and livelihoods.

The dry season is also marked by high temperatures, often exceeding **30°C**, and low humidity, contributing to increased occurrences of seasonal drought and water stress. These conditions are exacerbated by land degradation and limited water infrastructure, affecting domestic use, livestock, and agricultural productivity.[15]

Overall, rainfall patterns in Kiryandongo District are becoming increasingly variable, marked by erratic onset of rains, intermittent dry spells, and occasional localized flooding. Coupled with the district's heavy dependence on rain-fed agriculture, these conditions intensify climate-related hazards for both host and refugee communities. Such variability places mounting pressure on water resources, crop productivity, and pasture availability, highlighting the urgent need for context-specific climate adaptation and resilience measures to safeguard water security, strengthen food systems, and support

Map 4 displays the spatial distribution of average annual rainfall across Kiryandongo District for the period 1981-2024, derived from long-term CHIRPS precipitation data. The northeastern areas, including Mutunda, generally receive **888 –1,121 mm annually**, reflecting moderate rainfall conditions. Areas encompassing Ranch 1, Ranch 37 settlements, and Bweyale experience slightly higher totals, falling within the **1,122 –1,317 mm**, which supports cropland, pasture regeneration, and water availability for local communities.

Central Kiryandongo, including Kiryandongo Town Council, also lies predominantly within the **1,122 – 1,317 mm** rainfall zone, indicating moderately high rainfall conducive to agriculture and livestock production. Southwestern areas, such as Kigumba and Kigumba Town Council, receive **1,318 – 1,581 mm** annually, while the southern tip around Masindi Port records the highest rainfall in the district, ranging from **1,582 – 2,428 mm.**

Overall, this rainfall distribution highlights a north-to-south gradient, with southern and southwestern parts of the district being more rainfall-abundant, while northern and northeastern areas experience comparatively drier conditions. These spatial differences have important implications for agricultural potential, pasture availability, and water resource management across Kiryandongo District.

Local farmers in Kiryandongo District report that rainfall patterns have become increasingly unpredictable and erratic, complicating seasonal farming decisions and crop management.[16] Rain often begins briefly and then ceases abruptly, or arrives outside of traditional planting windows, undermining moisture availability during critical crop establishment and growth phases. For example, farmers describe situations in which rain falls for a few days and is followed by prolonged dry spells that stress young crops and delay agricultural operations, reflecting broader shifts in rainfall variability observed across Uganda's rain-fed agricultural systems.[16] Such patterns are consistent with national evidence of changing rainfall onset, duration, and distribution, which has increased uncertainty for planting and reduced the reliability of seasonal rains.[18]

Map 4: Map showing Average Annual Rainfall (1981-2024) of Kiryandongo.

These changing weather patterns in Kiryandongo District are consistent with broader national observations of increasing climate variability in Uganda, where alternating dry conditions and intense rains have been linked to reduced agricultural productivity and heightened vulnerability for rain-fed households. Such variability complicates farmers' ability to schedule planting and crop management and contributes to water scarcity during extended dry spells.[17]

Farmers growing maize, cassava, bananas, and root crops face crop stress and lower yields from prolonged dry periods. In areas like Mutunda, Bweyale, and Kiryandongo Town Council, households rely on small-plot maize and cassava cultivation, which is vulnerable to delayed or irregular rainfall. In southern areas, including Kigumba, Kigumba Town Council, and Masindi Port, heavy rains after dry spells can cause runoff, localized flooding, and soil erosion, further reducing crop productivity.[18]

Extended dry periods also hinder pasture regeneration, forcing livestock keepers to travel longer distances to access grazing and water. Such conditions intensify water scarcity for both domestic and agricultural uses, undermining livestock productivity and household food security in the district particularly for communities without access to perennial water sources beyond seasonal rivers and wetlands.[19]

Overall, Kiryandongo District's climate is characterized by moderately high, bimodal rainfall with increasing variability, directly influencing crop productivity, pasture regeneration, water availability, and the livelihoods of both host and refugee populations. The growing unpredictability of rain onset, prolonged dry spells, and intermittent intense rainfall underscores the need for improved climate information services, climate-smart agricultural practices, and **strategic resilience-building** measures to support communities dependent on rain-fed agricultural systems.

Temperature

Over the past four decades, Kiryandongo District has experienced a significant rise in temperatures, with an increase of approximately **2.3 – 2.5°C,** a substantial warming trend for a single district. As shown in *Figure 2*, the most pronounced rise has occurred in recent years (**2020-2024),** indicating a possible acceleration in warming and a growing risk of extreme heat events.

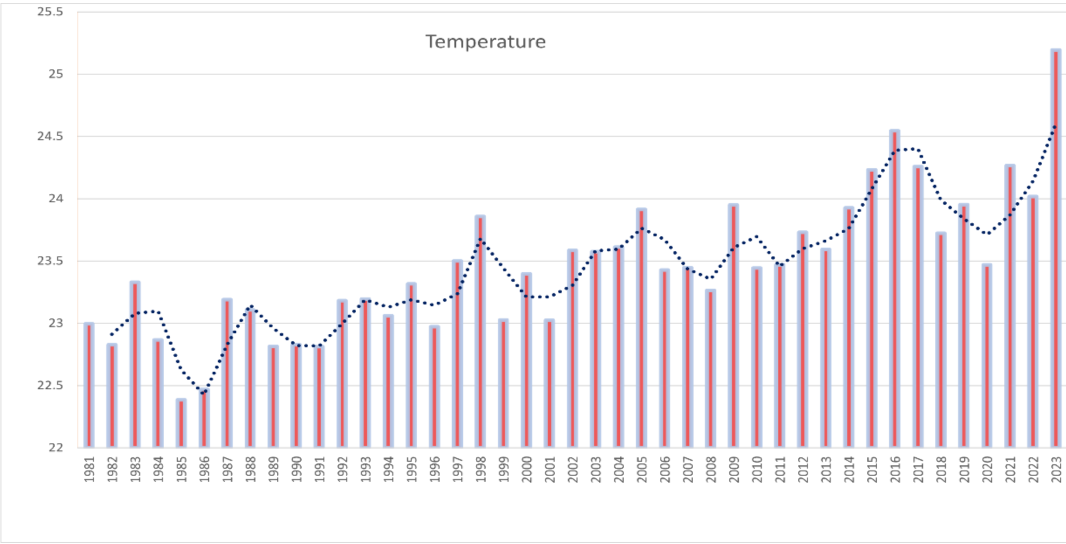


Figure 2: Graph showing the long-term temperature trend (1981-2023)

- **1980s-mid 1990s:** Average annual temperatures in Kiryandongo remained relatively stable, generally fluctuating between 22.9°C and 23.5°C, with limited year-to-year variability and no pronounced warming trend. This period reflects comparatively stable climatic conditions, with temperatures closely aligned to the long-term district mean.
- **Late 1990s-2014:** A gradual warming trend is evident, with average annual temperatures rising to around **23.5°C–24.5°C** in several years. While inter-annual variability remains moderate, this period marks a shift from earlier stability, signalling the onset of longer-term temperature increases in the district.
- **2015 onwards:** A clearer warming signal emerged, with most years recording averages above **24.5°C** and reaching **25.5°C** by 2022. While short-term fluctuations occurred, recent years represent the warmest period in the record, reflecting increasing temperature stress consistent with long-term climate change trends.

Overall, the temperature record for Kiryandongo highlights a **consistent upward trend**, signalling increasing climate stress. Rising temperatures are likely to exacerbate **evapotranspiration, soil moisture loss, and heat stress**, with implications for **rain-fed agriculture, water availability, livestock productivity, and human health**, particularly in refugee-hosting and rural communities.

Kiryandongo District experiences its warmest conditions during the **January–March dry season**, when clear skies and high solar radiation drive temperatures above the long-term monthly averages. Temperatures generally decline from **April through July**, reaching their lowest levels in mid-year, before gradually rising again from **August to December.** This seasonal cycle amplifies heat and water stress during dry periods, particularly when the onset of rainfall is delayed.

The long-term monthly temperature average (1981–2024), shown in *Figure 3*, displays a pronounced peak at the start of the year (January–February) and a secondary rise toward the end of the year (October–December). Temperature variability within the rainy seasons is relatively limited, with cooler conditions prevailing during the mid-year months.

Recent observations (2022-2024) highlight persistent warming relative to the long-term average, particularly during the early months of the year and toward the end of the year: The recent monthly temperature trend (2022-2024) can be summarized as follows:

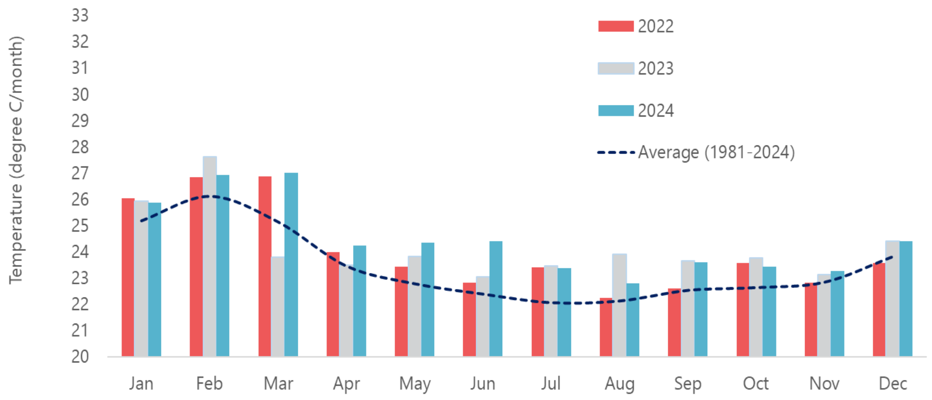


Figure 3: Graph showing average annual temperature (2022-2024) of Kiryandongo District.

- **2022:** Temperatures were generally close to the 1981–2024 long-term average during most months. During the first cropping season **(April–May)**, temperatures were slightly above the historical mean (23.4–23.8°C), indicating relatively warmer conditions. In contrast, the second season **(August–September)** recorded near-to slightly below-average temperatures, particularly in August **(22.2°C),** before rising above average again in October–December (**23.4 –23.6°C**).

- **2023:** Temperatures showed moderate positive deviations from the long-term average throughout the year. The first season **(April–May)** experienced above-average temperatures (**23.5 –23.8°C),** particularly in May. The second season **(August –September)** also recorded higher than average temperatures **(23.9 –23.6°C),** indicating warmer conditions during critical crop growth and development periods.

- **2024:** Temperatures were consistently above the long-term average across the year. During the first season **(April–June),** monthly temperatures remained elevated **(24.2 –24.4°C**), reflecting sustained heat stress. Similarly, the second season **(August–September)** recorded above-average temperatures (**22.8 –23.6°C)**, suggesting continued warmth during key crop establishment and growth stages.

Overall, Kiryandongo District shows increasing temperature anomalies during key crop growth periods, especially in 2023 and 2024. Above-average warmth during both the first **(April–June)** and second **(August–September)** cropping seasons is likely to increase evapotranspiration, reduce soil moisture, and heighten heat stress on rain-fed crops, potentially affecting yields and water availability. Above-normal temperatures negatively affect crops at all stages-reducing

- germination by accelerating metabolism, leading to depletion of energy reserves, impairing starch breakdown and causing poor root development before seedlings establish.
- flowering by hindering pollination, fertilization, and impairing chlorophyll function thus lowering carbohydrate supply, leading flowers to drop prematurely.
- seed development by reducing carbohydrate and oil accumulation in seeds, resulting in smaller seeds and thus lowering the seed germination potential of harvested seeds

Overall, the observed seasonal and intra-seasonal temperature patterns in Kiryandongo District point to increasing heat exposure during key agricultural periods, reinforcing concerns around rising climate-related stress on crops, water resources, and broader livelihood systems.

CLIMATE CHANGE PROJECTIONS

In this study, bioclimatic variables from WorldClim v2.1, which provide historical high resolution- baseline climate data, such as temperature and precipitation patterns, were compared with future climate projections generated by the UKESM1-0-LL Earth system model under the SSP2 - 4.5 scenario, which is considered a “middle-of-the road-” pathway. Under this scenario, socioeconomic development and moderate mitigation policies lead to stabilizing greenhouse gas emissions. This comparison allows researchers to assess how key climatic factors like seasonal rainfall, temperature extremes, and seasonal drought indices are expected to shift in coming decades, highlighting potential impacts on ecosystems, agriculture, and water resources under a moderately warming future.

Precipitation changes
(1970-2000 vs 2041-2060)
SSP2-4.5 Moderate Emission Scenario
Annual precipitation changes

+163 mm

Temperature changes
(1970-2000 vs 2041-2060)
SSP2-4.5 Moderate Emission Scenario
Annual Mean Temperature Increase

+2.4 °C

Figure 4: Annual precipitation and temperature changes in Kiryandongo District

Temperature

The mean annual temperature is projected to rise from **23.3°C** in the historical baseline to **25.7°C by 2041-2060**. Both minimum and maximum temperatures show substantial increases. The highest warming among the sub-counties and town councils **(about 2.34–2.40°C)** is expected in areas such as Kigumba, Masindi Port, Kiryandongo, Kigumba Town Council, Kiryandongo Town Council, and Bweyale Town Council. These areas are projected to experience warming levels that represent the upper end of the district’s temperature increase. In contrast, the ranch areas are projected to experience slightly lower but still significant warming **(about 2.33–2.35°C)**. This includes Kiryandongo Ranch 1 and Kiryandongo Ranch 37, which are expected to warm moderately while remaining consistent with the broader district warming trend.

Mean temperatures in the warmest month are projected to increase by approximately **+2.4°C**, while temperatures during the driest quarter are expected to rise by about **+2.6°C**. Together, these changes suggest intensified heat during already dry and high-temperature periods. This will likely compound dry-season stress by accelerating evapotranspiration, increasing soil moisture loss, and raising water demand for crops, livestock, and domestic use.

Similarly, mean temperatures in the coldest month are projected to increase by approximately **+2.3°C**, while the wettest quarter shows the largest projected rise at about **+2.4°C**. This indicates that even the traditionally cooler months will become significantly warmer in Kiryandongo District, reducing seasonal relief from heat. The sharp increase during the wettest quarter could heighten evapotranspiration during peak rainfall periods, potentially offsetting rainfall gains and increasing crop water requirements despite wetter conditions.

Overall, these projections indicate sustained warming throughout the year in Kiryandongo District, with elevated temperatures occurring during both the dry and wet seasons. This trend suggests increasing climate-related stress on critical sectors such as agriculture and water resources, while also heightening vulnerability among communities that depend on climate-sensitive livelihoods.

+ 2.4 °C — *Increase in mean temperature in the warmest month*

+ 2.6 °C — *Increase in mean temperature in the driest quarter*

+ 2.3 °C — *Increase in mean temperature in the coldest month*

+ 2.4 °C — *Increase in mean temperature in the wettest quarter*

Figure 5: Projected changes in temperature in bioclimatic variables.

Precipitation

Mean annual rainfall is projected to increase from **1,209 mm** to **1,372 mm** by mid-century. However, the distribution of rainfall gains is uneven across Kiryandongo District. Among sub-counties and town councils, moderate increases of 160–166 mm are expected in **Bweyale Town Council, Kigumba Town Council, Kigumba, Kiryandongo Town Council, and Kiryandongo**, while **Mutunda** records the highest gain (172 mm) and **Masindi Port** the lowest (153 mm). The settlement areas high increases, with Ranch 1 and Ranch 37 receiving ~167 mm and ~165 mm, respectively.

Precipitation in the **wettest month** is projected to increase by approximately **+31.4 mm**, while rainfall during the **coldest quarter** is expected to rise by about **+65.6 mm**. These increases heighten the likelihood of intense rainfall events, surface runoff, localized flooding, and soil erosion, particularly in low-lying and poorly drained areas.

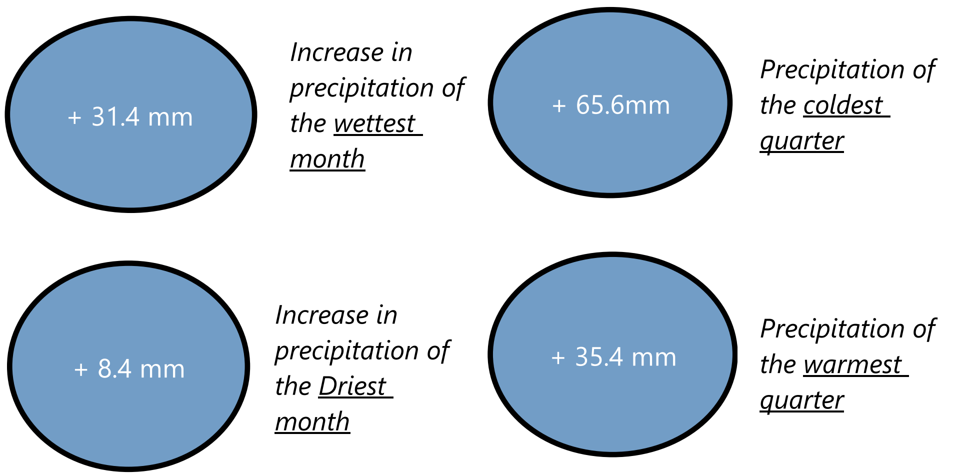
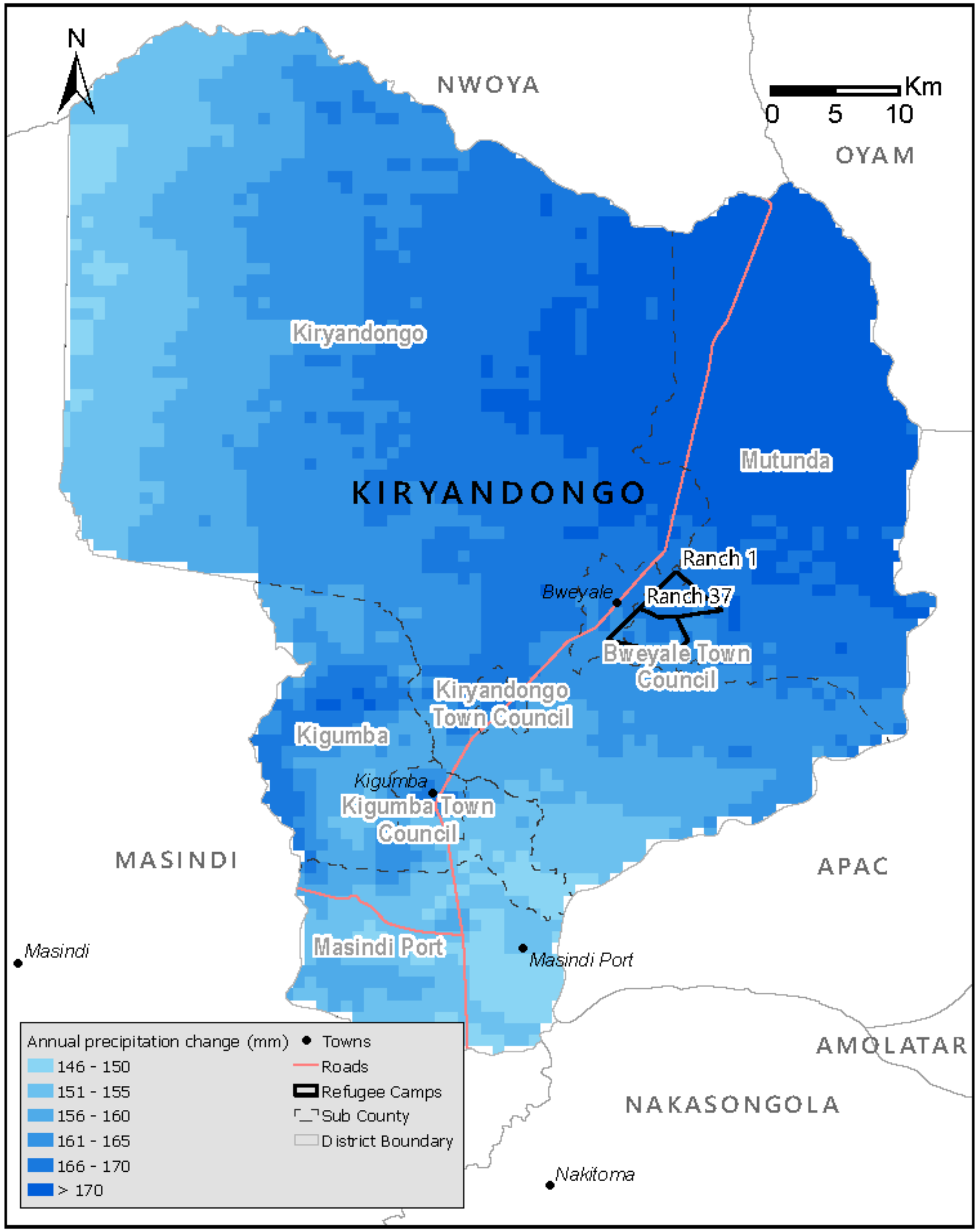


Figure 6: Projected changes in precipitation in bioclimatic variables



Map 5: Map showing projected precipitation changes from the baseline (1970-2000) to the near future (2041-2060).

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In contrast, precipitation during the driest month is projected to increase only slightly, by around **+8.4 mm**, while the warmest quarter is expected to receive an additional **+35.4 mm** of rainfall. The limited increase during the driest month suggests minimal improvement in dry-season water availability, whereas the larger rise in the warmest quarter may exacerbate rainfall intensity during already hot and humid periods.

Collectively, these projections indicate a future climate characterized by greater temporal concentration of rainfall, with only marginal gains in dry-season precipitation. This pattern implies continued vulnerability to hydrological stress during dry periods and an elevated risk of flooding or soil saturation during peak rainfall episodes

Implications

The combination of rising temperatures, uneven increases in precipitation, and seasonal shifts in rainfall distribution creates a complex climate-hazard profile for Kiryandongo District. Projected increases in mean annual temperature **(+2.4°C to +2.6°C by 2041–2060**), particularly pronounced in **Kigumba, Masindi Port, Kiryandongo, Kigumba Town Council, Kiryandongo Town Council, and Bweyale Town Council,** are likely to intensify heat stress during both dry and wet periods. Elevated temperatures will accelerate evapotranspiration, increase soil moisture loss, and raise water demand for crops, livestock, and domestic use, potentially limiting the benefits of modest rainfall gains. Even the traditionally cooler months are projected to warm, reducing seasonal relief from heat.

Sub-counties and settlements such as **Mutunda, Bweyale Town Council, and Ranch 1**, which are projected to receive relatively higher rainfall increases, may face elevated/more risks of intense rainfall events, localized flooding, surface runoff, and soil erosion, particularly in low-lying and poorly drained areas. Conversely, areas with smaller projected rainfall gains, including Masindi Port and Kiryandongo, are likely to remain vulnerable to seasonal drought, water scarcity, and crop moisture stress, especially during the driest month when precipitation is projected to increase by only **+8.4 mm**.

These shifts have direct implications for agriculture, livestock production, water infrastructure, and household resilience. Crops may experience moisture deficits during the dry season while also facing waterlogging and erosion risks during peak wet-season rainfall. Pasture availability for livestock is likely to fluctuate, affecting fodder supply, milk production, and household incomes. Water systems and domestic water access may be increasingly stressed, with communities confronting competing demands during dry periods and heightened flood risk during intense rainfall episodes. Overall, these projections indicate that Kiryandongo District will experience both hydrological stress in dry periods and heightened vulnerability to extreme rainfall events, necessitating targeted adaptation and water management strategies.

The projected warming and rainfall patterns in Kiryandongo district align closely with broader national and regional climate trends. According to the Uganda Third National Communication to the UNFCCC[20] and the IPCC Sixth Assessment Report[21], mean temperatures across Uganda are expected to rise by **1.5-2.5°C by mid-century**, while rainfall is projected to increase with greater variability and intensity. The district level projections for Kiryandongo, including intensified dry-season heat and concentrated wet-season rainfall, fall within these ranges, indicating that the district is experiencing climate shifts consistent with regional patterns.

This analysis highlights the importance of implementing targeted adaptation strategies in Kiryandongo District. Approaches such as climate-smart agricultural practices, rainwater harvesting and storage, soil fertility and pasture management, and flood risk mitigation will be essential to sustain livelihoods, protect food security, and enhance community resilience in the face of projected increases in temperature and uneven rainfall distribution.

SEASONAL DROUGHT HAZARD ASSESSMENT

Kiryandongo District faces rising seasonal drought risk from rainfall variability and recurrent dry spells, threatening agriculture and livelihoods. Both host communities and refugees, particularly in Ranch 1 and Ranch 37, are exposed to meteorological and vegetation droughts, which disrupt planting, reduce yields, and increase food insecurity.[24]

This analysis applies the *Standardized Precipitation Index (SPI)*, a precipitation-based indicator that measures precipitation/rainfall anomalies by comparing observed rainfall to historical averages, and the *Vegetation Condition Index (VCI),* an NDVI2 based indicator that shows crop biomass and vegetation health responses to precipitation anomalies/moisture stress. Together, these indices capture both meteorological drought conditions and their impact on vegetation, providing an integrated understanding of seasonal drought occurrence and severity.

The impacts of seasonal drought have become increasingly evident in Kiryandongo District, with prolonged dry spells and severely dry conditions affecting agricultural production, rangelands, and water availability, particularly in sub counties such as Bweyale, Mutunda, and the areas hosting Ranch 1 and Ranch 37 refugee settlements. While agencies such as WFP, UNHCR, and other partners district authorities have supported affected populations through food assistance and livelihood interventions, recurring seasonal drought events highlight the need for **sustained investment in drought preparedness, climate-resilient livelihoods, water infrastructure, and long-term adaptation measures.**[22]

SPI Findings

The *Standardized Precipitation Index (SPI)* analysis shows that **March–May 2024** was a critical period for assessing seasonal drought, as it coincides with the flowering season of first-season crops. In Kiryandongo District, most sub counties and town councils including **Kiryandongo Town Council, Bweyale Town Council, Kigumba Town Council, Mutunda, and Masindi Port** experienced severely dry precipitation conditions. The Kiryandongo Refugee Settlement was an exception, experiencing

Map 6: Map showing the SPI Index.

[2] NDVI stands for the Normalized Difference Vegetation Index.

moderately dry conditions, while **Ranch 1 and Ranch 37 refugee settlements** were also severely dry. No areas in the district were classified as extremely dry during this period.

These moderately dry to severely dry conditions indicate substantial impacts on soil moisture availability, crop growth and yield, rangeland conditions, and access to water resources, particularly in areas overlapping with refugee settlements where livelihoods are already highly sensitive to rainfall variability. Reduced rainfall during this critical cropping period may lead to lower crop yields, diminished forage for livestock, and increased pressure on domestic and agricultural water supply, highlighting the vulnerability of both host communities and refugee populations to climate variability.

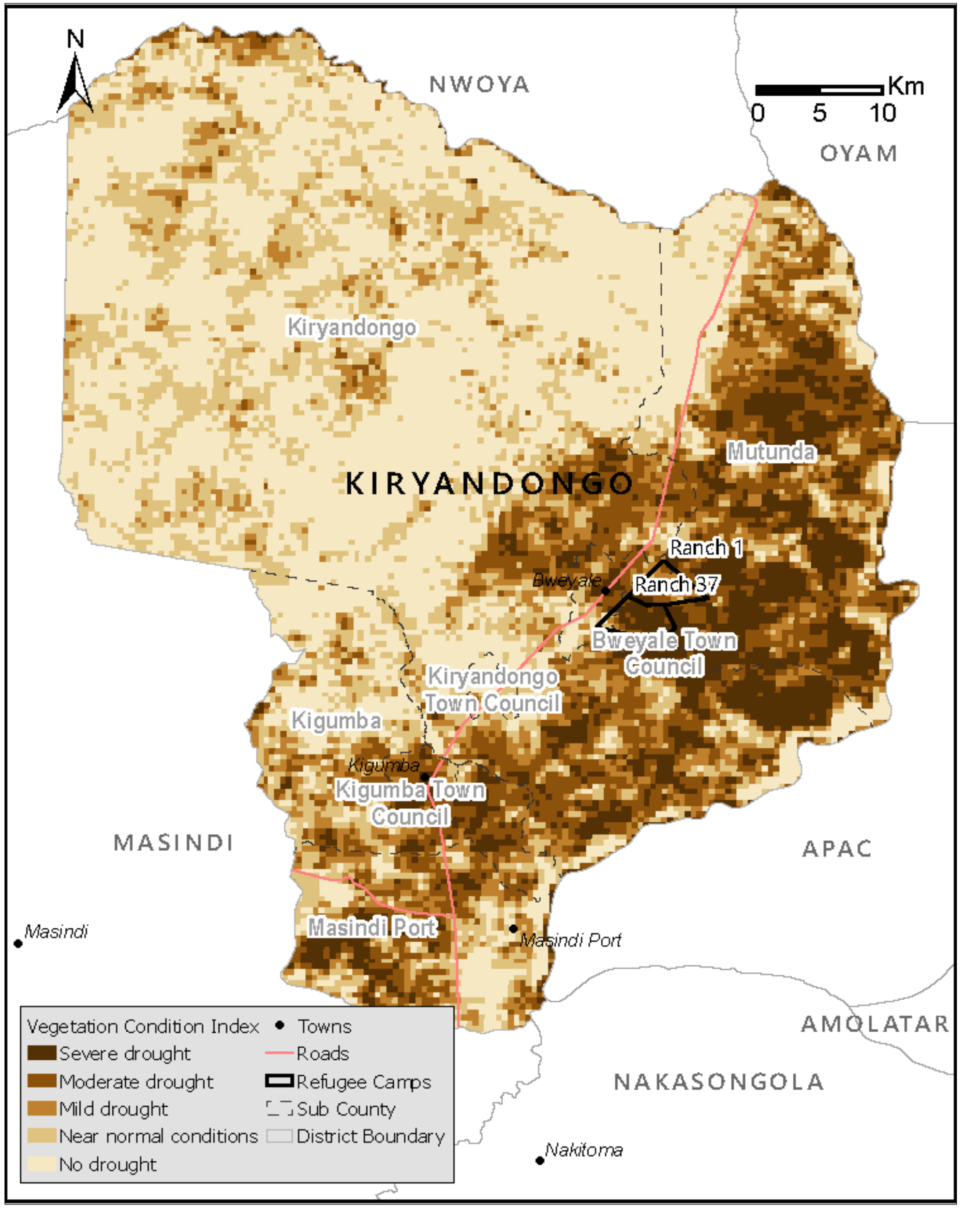
VCI Findings

The central and northern parts of **Kiryandongo District, including Bweyale Town Council, Mutunda Subcounty, and the Ranch 1 and Ranch 37 refugee settlements,** show severe vegetation seasonal drought (*see map 7).* These areas fall within the 1,122–1,317 mm rainfall zone. Yet they are largely dominated by cropland and built-up areas, which may explain the severe vegetation stress despite relatively moderate rainfall levels. The concentration of settlements and agricultural activities in these locations likely reduces vegetation cover and increases vulnerability to seasonal drought conditions.

In contrast, the southern and central areas, including **Kiryandongo Subcounty and Kigumba Town Council,** show mild to moderate vegetation drought. These areas receive about 888–1,121 mm of rainfall and are mainly composed of cropland with some grassland and scattered forest patches, which may help maintain relatively better vegetation conditions compared to heavily cultivated or built-up areas.

The western part of the **district around Masindi Port** shows moderate vegetation drought, despite receiving similar rainfall levels (888–1,121 mm). This area contains a mix of forest, cropland, and wetlands along river systems, and the presence of forest and wetland ecosystems likely supports better vegetation resilience compared to areas dominated by cropland and settlements.

Overall, vegetation health in Kiryandongo District is influenced by both rainfall variability and land use. Areas dominated by cropland and built-up land, especially around Bweyale and refugee settlements, experience higher vegetation stress, while



Map 7: Map showing VCI Index

forest and wetland areas like Masindi Port show better vegetation conditions. These patterns directly affect croplands and grazing areas that support local livelihoods.

Implications

Analyses of SPI and VCI indicate that Kiryandongo District is experiencing seasonal drought conditions that go beyond short-term rainfall variability, affecting agriculture, food security, water resources, and overall community well-being. Moderately to severely dry SPI conditions and moderate to severe vegetation stress in areas such as Bweyale Town Council, Mutunda Subcounty, and the Ranch 1 and Ranch 37 refugee settlements highlight heightened vulnerability during critical agricultural periods, with cascading impacts on household and community livelihoods.

These adverse conditions have tangible impacts on agricultural systems. During the March–May 2024 first season cropping period, when rainfall is most critical for crop establishment and flowering, extended dry spells and reduced soil moisture disrupted normal crop development. For example, local farmers in Kiryandongo reported that rainfall would start and stop abruptly, followed by prolonged dry periods that stressed crops, prompting some households to adopt small-scale irrigation, water harvesting, and other moisture-conservation practices to sustain production.[18]

Local evidence from Kiryandongo District shows that **erratic rainfall and prolonged dry conditions are significantly affecting agricultural performance, vegetation cover, water resources, and community livelihoods**. Farmers increasingly report unpredictable rainfall patterns, with prolonged dry spells and limited precipitation making rain-fed agriculture less reliable. This leads to crop stress and reduced yields. For example, the traditional first rains in March have become unreliable, exposing crops to moisture stress during critical growth stages and limiting soil moisture for staple cereals and legumes.

Reduced rainfall and prolonged dry spells in Kiryandongo District are undermining vegetation health, particularly affecting pasture and grazing conditions for livestock. Persistent dry conditions have made local grazing fields less reliable, forcing households to travel longer distances to access fodder and water during the dry season. Extended seasonal drought periods have increased livestock vulnerability, with observed impacts including reduced milk production, lower weight gain, and heightened risks to household food security, as both forage availability and water points diminish.[23]

Water scarcity is an increasing concern in Kiryandongo District. Prolonged dry seasons and erratic rainfall reduce the reliability of water sources such as shallow wells, springs, and rivers for domestic, agricultural, and livestock use. During extended dry periods, residents, especially women and children, must travel long distances to access water, increasing labor demands and compromising hygiene and sanitation. These conditions exacerbate competition for limited water resources and heighten water stress across farming and pastoral households.[31]

Seasonal drought in Kiryandongo District impacts public health and livelihoods. Dry conditions increase dust and respiratory issues, especially for children and the elderly. Limited water compromises hygiene, worsening health in densely populated and refugee areas like Ranch 1 and Ranch 37. Precipitation deficits (SPI) and vegetation stress (VCI) correlate with reduced agricultural productivity, degraded pasture and vegetation, water scarcity, and overall household stress.

These findings highlight the need for early warning systems, climate smart agriculture, and improved water harvesting and storage. Integrating SPI and VCI monitoring into district disaster management can enable timely seasonal drought alerts, guide planning, and strengthen both immediate response and long-term resilience in Kiryandongo District.

In Kiryandongo, drought and unpredictable weather have caused failed harvests, leaving many farmers, including refugees, with low crop yields. Limited land and high costs make farming difficult. Locals are calling for climate-smart agriculture, irrigation access, and training to prevent future losses.

Source: New vision - Failed harvest threatens local farmers of Kiryandongo refugee settlement

Photo 1: Failed harvest threatens local farmers of Kiryandongo refugee settlement. Photo Credit: New vision

REACH Informing more effective humanitarian action

FLOOD HAZARD ASSESSMENT

Flood susceptibility refers to how likely an area, community, or system is to experience harmful impacts from flooding, based on physical, environmental, and socio-economic factors. Several factors determine how an area exposure to flood is ranked from low to high. These factors include hydrological (e.g. intensity and duration of rainfall), geographical (proximity to rivers, soil type, and topography), land use and community livelihood types.

For this assessment thirteen indicators were analysed by ranking into five score levels to flood risk.[24] The score rank of the thirteen indicators was summed and ranked into three level of risk.

1. Distance to Permanent water ranked from higher risk to lower risk at 100 meters, 250 meters, 500 meters, and 750 meters.[25]
2. Elevation above sea level ranked from higher risk to lower risk at 600 meters, 700 meters, 800 meters, and 1000 meters.[26]
3. Slope of the area in degrees ranked from higher risk to lower risk at 2, 5, 10, 15.[27]
4. Landcover ranked from higher risk to lower risk as built-up, cropland (include water, flooded vegetation), grassland, shrub and forest.[28]
5. Topographic Position Index ranked from higher risk to lower risk at -8, -6, -4, -2, 0.
6. Normalized Difference Vegetation Index ranked from higher risk to lower risk at 0.2, 0.4, 0.6, 0.8[29]
7. Normalized Difference Water Index (NDWI ranked from higher risk to lower risk at 0.6, 0.2, -0.2, -0.6.
8. Flood Return period ranked from higher risk to lower risk at 10 years, 20 years, 50 years, 100 years, 200 years.[30]
9. Rainfall Intensity as average maximum annual rainfall ranked from higher risk to lower risk at 33 mm, 31 mm, 29 mm, 27 mm.[31]
10. Monthly Number of Days with Rainfall ranked from higher risk to lower risk at 13 days, 10 days, 7 days, 3 days.[32]
11. Frequency of -days with continuous Rainfall ranked from higher risk to lower risk at 2, 1.2, 0.8, 0.4.[33]
12. Height Above Nearest Drainage (HAND) ranked from higher to lower susceptibility at 2 meters, 5 meters, 10 meters, 20 meters.[34]
13. Soil texture ranked from higher risk to lower risk with (clay, clay loam, silty loam), (silty clay, silty clay loam), (sandy clay, sandy clay loam), (loam, sandy loam), (loamy sand, sand).[35]

Height Above Flood susceptibility mapping relies on integrating multiple environmental, hydrological, and climatic indicators to assess risk levels. Recent literature emphasizes that parameters such as proximity to water bodies, elevation, slope, land cover, vegetation indices, and rainfall characteristics are critical determinants of flood vulnerability. Studies highlight that areas closer to permanent water sources, with low elevation and gentle slopes, are more prone to inundation. Similarly, built-up and cropland land covers tend to amplify flood risk due to reduced infiltration capacity, while vegetation indices (NDVI, NDWI) provide insights into soil moisture and vegetation health, which influence runoff and water retention. The inclusion of topographic indices like HAND and TPI further refines susceptibility mapping by capturing micro-topographic variations that affect drainage and water accumulation

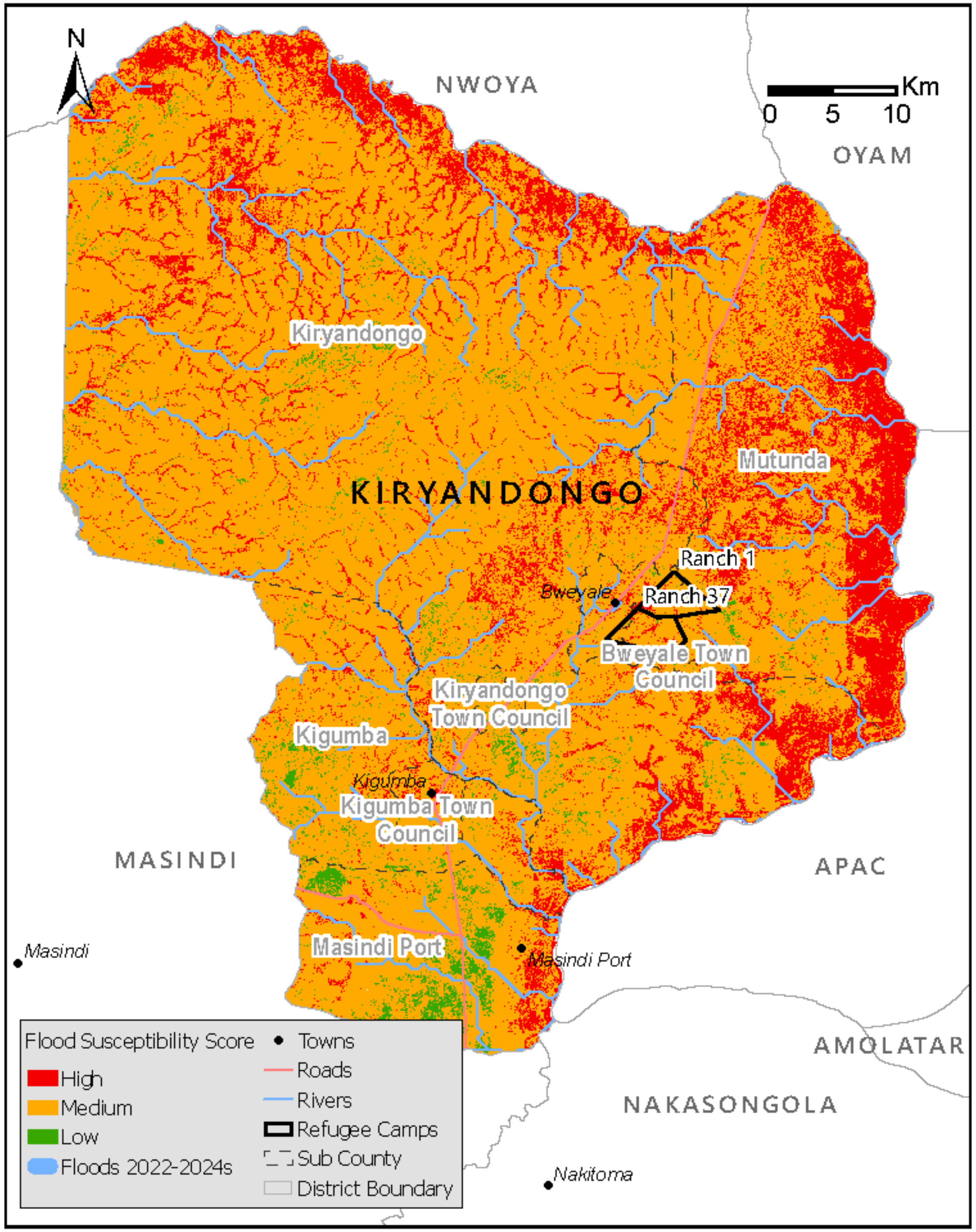
Hydro-climatic indicators such as rainfall intensity, frequency of continuous rainfall days, and flood return periods are equally vital in flood risk assessment. Literature shows that extreme rainfall events, particularly when sustained over consecutive days, significantly increase flood hazards. Soil texture also plays a crucial role, with clay-rich soils exhibiting lower infiltration rates and higher runoff potential compared to sandy soils. Integrating these thirteen indicators into a composite scoring system aligns with established frameworks that rank susceptibility into multiple risk levels. Such multi-criteria approaches are widely recommended because they capture the complex interplay between terrain, hydrology, and climate, thereby improving the accuracy of flood hazard mapping and supporting disaster risk reduction strategies.

Findings

Flood risk in Kiryandongo District is shaped by a combination of topography, rainfall distribution, land use, and settlement patterns, making several areas particularly susceptible to seasonal flooding. Flood susceptibility mapping shows **that Mutunda, Bweyale Town Council, and Masindi Port fall largely within high flood-susceptibility zones, especially along riverbanks and low-lying areas.** In contrast, **Kiryandongo and Kigumba**, including **Kigumba Town Council**, show predominantly medium susceptibility, although localized pockets of higher risk exist. The refugee settlement areas of **Kiryandongo Ranch 1 and Kiryandongo Ranch 37** are also located within high flood-risk zones, increasing exposure for already vulnerable populations.

These hazards are reinforced by the district's elevation (approximately **710–1,319 m** above sea level) and the presence of flat valley floors near the Victoria Nile and its tributaries, where water tends to accumulate during heavy rains. Although much of the district consists of **forest (53%)** and **cropland (23%),** the combination of expanding agriculture, **grassland areas (20%),** and limited wetland coverage reduces the landscape's natural capacity to absorb excess runoff. Additionally, rainfall patterns show a **north–south** gradient, with **southern areas** such as **Masindi Port** receiving the lowest rainfall totals, which further elevates flood potential in the northern locations.

Increasing rainfall variability, erratic onset of rains, and localized heavy storms have also contributed to more frequent waterlogging and flash flooding. Communities in both host and refugee settlements report that rains often come intensely and unpredictably, followed by dry spells, which increases surface runoff rather than gradual infiltration. As a result, flooding can damage crops, disrupt transport infrastructure, and threaten homes and social services, particularly in low-lying agricultural and settlement areas. Strengthening climate-resilient land management, drainage systems, and early warning mechanisms will therefore be critical to reducing flood risks and protecting livelihoods in the district.



Map 8: Map of Kiryandongo District showing Flood Susceptibility (2022-2024).

Risk on cropland and Settlement

The land cover analysis **in Kiryandongo District shows that forest covers 53%, cropland 23%, grassland 20%, while wetlands and built-up areas each account for about 2% of the district's land area.** Flood susceptibility mapping indicates that several cropland and settlement areas fall within medium to **high flood-risk zones, particularly in Mutunda, Bweyale Town Council and Masindi Port. Built-up areas and refugee settlement zones, including Ranch 1 and Ranch 37,** emerge as particularly exposed due to their location in high-susceptibility zones. However, these estimates represent district-wide averages and may mask localized concentrations of flood impacts at sub-county and settlement levels.

The land use and land cover map for Kiryandongo District shows that croplands are concentrated around settlement centres and river valleys. Important areas include Mutunda, Bweyale Town Council, and Masindi Port. These locations are mostly in high flood hazard zones. About 78.5% of cropland lies in medium flood risk areas. Built-up areas, including refugee settlements in Kiryandongo Ranch 1 and 37, are also flood prone. Around 74.3 % of built-up land is in medium flood hazard zones. This exposes households, crops, and infrastructure to frequent flooding

Kiryandongo District's low-lying river valleys, floodplains, and settlement corridors increase flood vulnerability, particularly on poorly drained valley bottoms and riverbanks where agriculture and settlement expansion amplify seasonal hazards. Effective management requires improved drainage, wetland and river buffer restoration, community early warning systems, and integration of flood risk into land-use, agriculture, and settlement planning to protect livelihoods.

The flooding trend in Kiryandongo District corresponds with periods of heavy and erratic rainfall, particularly in southern areas such as Masindi Port, indicating a strong link between climatic variability and local hydrological responses. Additionally, expanding cropland, settlements, and refugee-hosting areas, especially in Mutunda, Bweyale Town Council, and Kiryandongo Ranch 1 and 37, have reduced natural infiltration and increased surface runoff, amplifying flood frequency and severity. Overall, the spatial and temporal pattern points to persistent flood exposure in low-lying river valleys, floodplains, and poorly drained settlement corridors, posing increasing challenges for agriculture, infrastructure, and community livelihoods.

Flood Impacts

Flooding in Kiryandongo District has caused significant social, economic, and environmental challenges. Recurrent inundation has led to damage of crops and agricultural land, disrupting food production and household income for both host and refugee communities. Access roads and footpaths in flood-prone areas become impassable during heavy rainfall, affecting mobility and access to markets, schools, and health facilities.[36] Floods have also contaminated water sources and damaged sanitation facilities, increasing the risk of waterborne diseases, particularly within the refugee settlement zones.[37]

Photo 1: Temporary settlement areas were also submerged at Wakisanyi Village in Kiryandongo District in November 2023. Photo Credit: Dan Wandera

In **November 2023**, heavy rains caused River Kafu to overflow, flooding Hoima, Kyankwanzi, Masindi, Nakasongola, and Kiryandongo districts. Over 2,000 households were displaced as homes and infrastructure, including roads, bridges, and schools, were submerged. Crops were destroyed, disrupting food security and incomes, while standing water and damaged sanitation raised risks of waterborne diseases. Source: Daily Monitor -River Kafu floods leave 5 districts in ruins

Photo 2: Residents using a boat to cross the flooded Kikaito-Bakyeyo Road in Kiryandongo district, Photo Credit: Innocent Atuganyira.

In **2022**, heavy rains and flooding submerged the Kikaito-Bakyeyo road in Kiryandongo District, isolating communities and making key routes impassable. The flooded road forced children to miss school and left pregnant mothers unable to reach health centres, leading some to deliver at home under risky conditions. Farmers also struggled to transport produce to markets, affecting livelihoods and access to services.

Source: UG reports - Residents using a boat to cross the flooded Kikaito-Bakyeyo Road in Kiryandongo district

Environmentally, it drives soil erosion, stream sedimentation, and loss of vegetation, undermining natural drainage systems and heightening the risk of future floods. Socially, households in affected areas frequently face temporary displacement, property damage, and increased vulnerability due to inadequate infrastructure and limited adaptive capacity. These compounded impacts underscore the need for integrated flood management, targeted infrastructure improvements, and community-based adaptation strategies to enhance resilience across the district.

Conclusion

The findings of this geospatial analysis highlight the significant impact of climate-related hazards on both host and refugee communities in Kiryandongo District. Over the assessment period, the district experienced moderate to severe seasonal drought conditions during the **March–May 2024** first-season crop flowering, alongside recurrent localized flooding, which together threaten agricultural productivity, water availability, and settlement infrastructure. SPI and VCI analyses reveal substantial rainfall deficits and vegetation stress, particularly in **Bweyale, Mutunda, and the Ranch 1 and Ranch 37 refugee settlements**, while flood mapping indicates high exposure in low-lying areas such as **Mutunda, Bweyale Town Council, Masindi Port, and refugee settlements.** These findings underscore the growing climate vulnerability of Kiryandongo District, emphasizing the need for targeted adaptation measures including early warning systems, climate-resilient agriculture, water harvesting infrastructure, and integrated flood and settlement planning to safeguard livelihoods and enhance resilience for both refugee and host populations.

Methodology Overview

The climate hazard assessment for Kiryandongo District used a combined geospatial, remote-sensing, and climate-modelling approach integrating historical baselines, future projections, and hazard-specific analyses. Historical climate conditions (1970-2000) were derived from WorldClim v2.1 using BIO1 (Annual Mean Temperature) and BIO12 (Annual Precipitation), clipped to the district and summarised through spatial and statistical analysis. Future projections for 2041-2060 were obtained from the UKESM1-0-LL model[38] under the SSP2-4.5 scenario, processed using the same bioclimatic variables to ensure comparability with the historical baseline.[39]

Seasonal drought assessment followed UN-SPIDER protocols[40], using SPI calculated in Google Earth Engine (GEE)[41,42] from CHIRPS rainfall data[43] (2014-2024) and VCI derived from NDVI time-series to measure vegetation stress. Agricultural and rangeland areas were manually delineated to improve spatial accuracy, and VCI classification followed Kogan (1995) standards.[44] Outputs were visualized and analysed in ArcGIS.

Flood mapping was conducted using Sentinel-1 SAR imagery processed in GEE to identify inundation for 2022-2024.[45] Annual flood layers were imported into ArcGIS, where raster summation generated a districtwide flood-frequency map. Together, the historical and projected climate datasets, SPI-VCI drought indicators, and multi-year flood mapping provide an integrated picture of climate hazards affecting both host communities and the Kiryandongo Refugee Settlement in Kiryandongo District.

Limitations

The assessment primarily relied on remote-sensing and global climate datasets, which, while widely used, may not fully capture localized micro-climatic variations or ground-level conditions affecting vulnerability. Community-level vulnerability indicators such as coping capacity, water access constraints, and infrastructure fragility were not systematically integrated due to limited available data. Field verification of seasonal drought and flood extents was not conducted, though the satellite image processing followed established and validated UN-SPIDER protocols.

Further background information can be found in the Climate Risk Profiles for Refugee-Hosting Districts in Uganda Terms of Reference (TOR).

Note on Data Sources

Historical climate estimates in this report use both WorldClim (1970-2000 climatology) and ERA5-Land (1981-2024 reanalysis). These datasets use different observational networks, spatial resolutions and interpolation/assimilation methods and consequently report slightly different estimates of mean annual temperature for Kiryandongo District (WorldClim ≈ 25.7°C for 1970-2000, ERA5-Land ≈ 24.7°C for early 1980s-2000). These differences are within the expected uncertainty range for gridded climate datasets and do not affect the overall interpretation of a warm tropical baseline and a clear recent warming trend. All historical temperatures in this report should therefore be understood as approximate values in the mid-20s (around 25-26°C) rather than exact point estimates.

To view/access the Climate Hazard Analyses for any of the following districts:

- Adjumani District
- Koboko District
- Yumbe District
- Terego District
- Madi Okollo District
- Lamwo District
- Obongi District
- Kyegegwa District
- Kiryandongo District
- Kamwenge District
- Kikuube District
- Isingiro District

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Definitions

Hazards: A process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation.[46]

Flood: The overflow of water onto land that is normally dry, resulting from the temporary inundation of areas due to factors such as intense or prolonged rainfall, river overflow, surface runoff, or failure of water control structures. Floods can vary in scale and duration and may cause damage to infrastructure, livelihoods, ecosystems, and human health.[47]

Flood Susceptibility: The likelihood of flooding occurring in an area based on physical, environmental, and climatic factors such as topography, rainfall intensity, and proximity to water bodies.[48]

Seasonal drought: A temporary period of below-average rainfall within a specific season, resulting in soil moisture deficits and vegetation stress, particularly during critical agricultural periods.[49]

Meteorological drought**:** A period of abnormally dry weather sufficiently prolonged to cause a serious hydrological imbalance, typically defined by a lack of precipitation relative to the long-term average[50]

Exposure: The situation of people, infrastructure, housing, production capacities and other tangible human assets located in hazard-prone areas.[51]

Risk: The potential loss of life, injury, or destroyed or damaged assets which could occur to a system, society or a community in a specific period, determined probabilistically as a function of hazard, exposure, vulnerability and capacity.[52]

Water Stress: Water stress occurs when the demand for water exceeds the available amount during a certain period or when poor quality restricts its use. Water stress causes deterioration of freshwater resources in terms of quantity (aquifer over-exploitation, dry rivers) and quality (eutrophication, organic matter pollution, saline intrusion).[53]

Disclaimer

This report provides an evidence-based overview of climate trends, hazards, and projected impacts in Uganda's refugee-hosting districts to support informed planning and decision-making. The analysis draws on historical climate datasets, remote sensing products, and modelled projections, all of which are subject to inherent uncertainties, assumptions, and methodological limitations.

The drought assessment presented in this report focuses primarily on seasonal drought conditions, using indicators such as the Standardized Precipitation Index (SPI) and the Vegetation Condition Index (VCI). These indicators capture short- to medium-term rainfall deficits and vegetation stress within specific seasons and should not be interpreted as representing long-term or permanent drought conditions.

Accordingly, the findings should be considered indicative rather than definitive, particularly at localized scales, where microclimatic variability, environmental conditions, and socio-economic factors may differ. While every effort has been made to ensure data accuracy, this report does not replace site-specific assessments or field verification.

The views expressed herein do not necessarily reflect those of any government, organization, or funding partner. This report should not be used as the sole basis for policy, investment, or operational decisions without further contextual analysis and validation.

Users are encouraged to complement these findings with local knowledge, stakeholder consultation, and additional data sources when designing interventions or resilience strategies.

In case of questions, feedback, or requests for tailored, area-specific remote-sensing products, kindly contact uganda@reach-initiative.org.

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ABOUT REACH

REACH Initiative facilitates the development of information tools and products that enhance the capacity of aid actors to make evidence-based decisions in emergency, recovery and development contexts. The methodologies used by REACH include primary data collection and in-depth analysis, and all activities are conducted through inter-agency aid coordination mechanisms. REACH is a joint initiative of IMPACT Initiatives, ACTED and the United Nations Institute for Training and Research - Operational Satellite Applications Programme (UNITAR-UNOSAT).

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