STATUS OF THE UGANDA CLAWED FROG, *Xenopus ruwenzoriensis*, AMIDST CLIMATE CHANGE AND HABITAT DEGRADATION
Project 242535234

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By

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Abstract

This study assessed the status of the Albertine Rift endemic Uganda Clawed Frog (*Xenopus ruwenzoriensis*) in Uganda, integrating species distribution modelling (SDM), field surveys, and community perceptions to evaluate current and future distribution patterns under climate change. Field surveys confirmed the presence of *X. ruwenzoriensis* in Semuliki National Park, where it exhibited high abundance in slow-moving streams, but no individuals were recorded in the higher-altitude Rwenzori Mountains National Park. MaxEnt modelling using current (1970–2000) and future (2021–2060) climate scenarios projected a dramatic northward and eastward expansion of suitable habitat under both SSP2-4.5 and SSP5-8.5 scenarios, with potential gains exceeding 50,000 km² (a >5,000% increase from the current ~962 km²). Despite this expansion, the species faces significant non-climatic threats including agricultural chemical runoff, oil effluent discharge, and negative community perceptions, especially among women. Community sensitization revealed mixed attitudes, with cultural beliefs both supporting and hindering conservation. The study concludes that while climate change may substantially increase the climatic niche of *X. ruwenzoriensis*, its actual range expansion will be constrained by habitat degradation and human activities. Targeted conservation strategies must address both environmental and socio-cultural barriers to ensure the species' long-term survival.

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1. Introduction

1.1 Background

As climate change continues to manifest globally, its implications on biodiversity have become increasingly evident (Chen1 et al., 2022; Vasconcelos et al., 2018). Specifically, amphibians are likely to be adversely affected (Alves-Ferreira et al., 2022; Lawler et al., 2010). Due to their fragile skin nature, amphibians have been found to be more sensitive to environmental changes as compared to other vertebrates (Bourke et al., 2018; Lawler et al., 2010), on addition, their unshelled and desiccation-prone eggs are highly affected by slight changes in temperature (Steigerwald, 2021), this has made them to be considered as environmental indicators for health ecosystems. According to Alves-Ferreira et al. (2022), climate change can impact amphibians in three ways; a) Pressuring them to relocate to new suitable habitats, b) necessitating adaptation to unfamiliar climatic conditions, or c) potentially leading to their extinction. It is estimated that 41% of world amphibians are threatened to extinction, with climate change worsening the situation by 30% for the already threatened species (IUCN SSC Amphibian Specialist Group, 2023). This study will investigate how climate change affects the spatial distribution of the Albertine endemic Uganda Clawed Frog using current and future climate scenarios and distribution models.

The Uganda Clawed Frog, *Xenopus ruwenzoriensis* Tymowska & Fishberg, 1973 is a dodecaploid anura species belonging to family Pipidae Gray, 1825 and it is the only polyploid in the family (Sammut et al., 2002; Schmid et al., 2015). *X. ruwenzoriensis* was first described by Tymowska & Fishberg in 1973 using chromosome complements, later, in 1978, Fishberg and Kobel described the species using exterior morphological structures. However, Tymowska & Fishberg (1973) was adopted as the author of *X. ruwenzoriensis* following taxonomic guidelines and Fishberg & Kobel (19 78) was taken to describe additional information relevant to the species (Reumer, 1986). The species is rare and endemic to the Albertine region. Its presence has only been recorded in Uganda and Democratic Republic of Congo with the former having majority of the records (IUCN SSC Amphibian Specialist Group, 2014; Masudi et al., 2019; Plumptre et al., 2017; Reumer, 1986). This region is region is already known to be threatened by climate change (Carr et al., 2013; Plumptre et al., 2017).

There has only been Thirty-seven (37) published records of the species in Uganda, majority of these records are more than twenty years old. The most recent record was in 2019 in Masindi District (GBIF 2024).

Therefore, there is need to study the status of the species and understand how factors like climate change, habitat degradation and community perceptions impact its presence and/or absence in the Albertine region.

1.2 Problem statement

The Albertine region is experiencing significant changes in its climatic conditions (Carr et al., 2013; Plumptre et al., 2017) and it is estimated that 34.5% of the amphibian species in the region are threatened by climate change (Carr et al., 2013). While existing research has mainly addressed the impact of agricultural conversion and climate change on habitat loss, a little is known on how climate change may affect the current and future spatial distribution rare species such as *Xenopus ruwenzoriensis*. The findings contribute essential information to guide

targeted conservation efforts and inform policymakers about the necessary measures to safeguard this species in the face of changing climatic conditions.

1.3 Objectives

1.3.1 Main objective
To investigate status of *Xenopus ruwenzoriensis* in Uganda.

1.3.2 Specific objectives
To assess the current and future spatial distribution patterns of *Xenopus ruwenzoriensis* in Uganda

To assess the threats in the habitat where *Xenopus ruwenzoriensis* is found

To understand local community perceptions on *Xenopus ruwenzoriensis* and sensitize them on amphibian conservation

1.4 Research questions

Where can *Xenopus ruwenzoriensis* be recorded within the project area?

What environmental threats exist in places where *Xenopus ruwenzoriensis* is recorded

How can climate change influence the spatial distribution of *Xenopus ruwenzoriensis*

What knowledge and perceptions do communities have on amphibian conservation.

2. Methodology

2.1 Study area

The Albertine Rift constitutes the western segment of the African Rift Valley, starting from the northern extremity of Lake Albert to the southern end of Lake Tanganyika. It passes through six countries: the eastern region of the Democratic Republic of Congo, the western part of Uganda, Rwanda, Burundi, Tanzania, and the northern part of Zambia(Kanyamibwa, 2013). Its altitude ranges from 600m to 5,100m above sea level, the area has a diverse range of vegetation types. This includes lowland rainforest, medium-altitude semi-deciduous rainforest, savanna grasslands and woodlands, Miombo woodland, papyrus wetlands, Carex wetlands, montane forest, Sinarundinaria bamboo, Oxytenanthera bamboo, Hagenia-Hypericum woodland, giant heather, giant Senecio and Lobelia, alpine moorland, bare rock, and bare earth(Ayebare et al., 2013). Six landscape types have been identified in the Albertine rift valley, these include: Murchison-Semuliki landscape, Greater Virunga landscape, Maiko-Itombwe landscape, Congo – Nile Divide, The Gombe-Mahale Southern Highlands landscape, and Marungu-Kabobo landscape(Ayebare et al., 2013; Carr et al., 2013; Kanyamibwa, 2013). However, this study will focus on the Murchison-Semuliki landscape and the Greater Virunga landscape where the species has been recorded before.

The Murchison-Semuliki landscape links Murchison Falls National Park through Budongo and Bugoma Forest Reserves, Kagombe, Kitechura, Muhangi, Itwara Forest to the Toro-Semuliki Wildlife Reserve at the southern end of Lake Albert while the Greater Virunga landscape includes Virunga National Park in DRC, Rwenzori Mountains National Park and contagious protected areas in western Uganda, and Volcanoes National Park in Rwanda(Carr et al., 2013; Kanyamibwa, 2013).

According to Carr et al., (2013) areas situated at high altitudes (above 2,000 m) experience average daily mean temperatures of approximately 15–17°C, with minimum temperatures reaching 0°C and below. Intermediate altitude locations (1,500–2,000 m) typically have mean temperatures ranging from 18–21°C, while lower altitude regions often see temperatures consistently surpassing means of 21°C. Although temperatures may exhibit significant variability on a local scale, seasonal temperature variations within individual locations are minimal.

In terms of precipitation, regions close to the equator have the primary rainy seasons in early May and September. North of the equator, around Murchison Falls and Semliki National Parks (approximately 0.5°–2°N), a bimodal rainfall pattern persists, but the shifts between wet and dry periods are less pronounced. There is unexplained reduction in rainfall, lasting about a week in the center of the October maximum. In more southern locations, (approximately 2°S), there is a transition between bimodal and unimodal annual rainfall patterns. Here, an 8.5-month wet season (early September – mid-May) with peaks at the beginning and end is typically followed by a 3.5-month dry season with intermittent rains. Moving even further south, (approx. 6°S), rainfall patterns become predominantly unimodal, characterized by a distinct rainy period from October to mid-May(Carr et al., 2013).

Field surveys focused on major rivers, streams and wetlands entering Semuliki National Park and the Northern side of Rwenzori Mountains National Park. These include Ssempaya river, Mbuga river, Ntoroko river, kirima stream, Sara stream, Mapongogi stream, Botwalinbo stream, nyakabasiri river, kanabogo river, Mpolya river and Tokwe river in Semliki. The areas in Rwenzori mountains include Mpolya river, Nyaryopyo, Wasa river, Muhire river, Nyakatare river.

The selection of some specific sites was be guided by the UWA field team depending on the reachability, security and other factors.
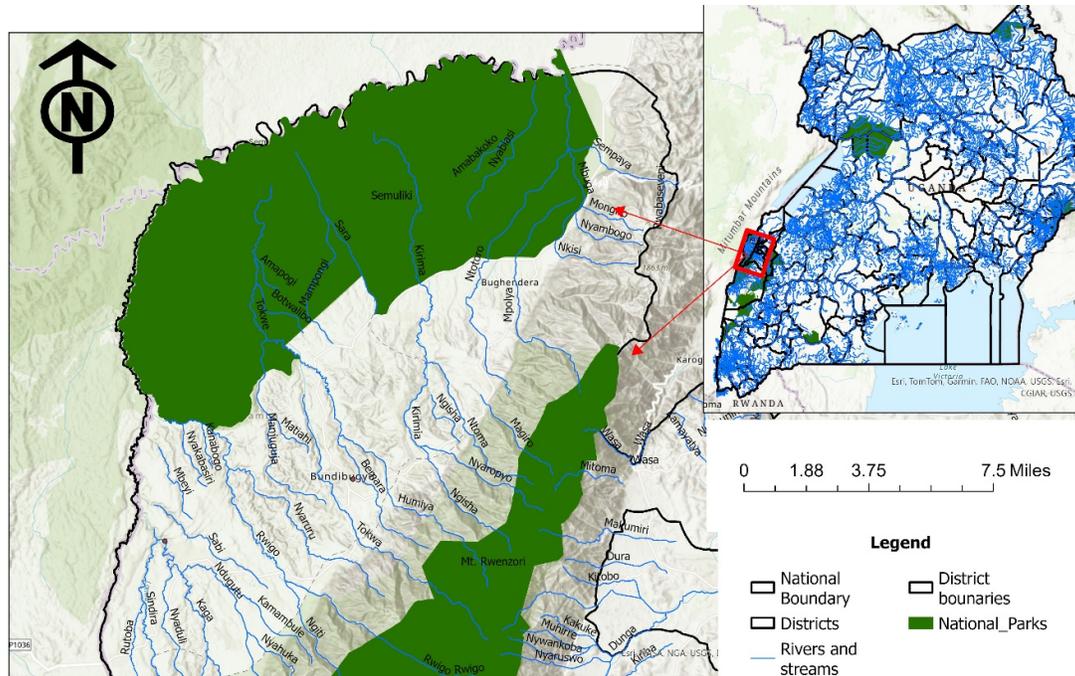

Figure 1: Map of the project area showing the major Streams and Rivers for Data Collection

2.2 Study design

The study employed a mixed-methods research design combining ecological modelling, field observations, and social surveys to assess the status of *Xenopus ruwenzoriensis*. The ecological component used a predictive modelling design, where species occurrence records and bioclimatic variables were analyzed using MaxEnt to determine current habitat suitability and project future distributions under different climate scenarios. An observational field survey design was used to obtain occurrence records. To complement the ecological findings, a cross-sectional survey design was adopted to document community awareness, perceptions, and perceived threats to amphibians through Focus Group Discussions and household questionnaires. The mixed-methods approach provided a holistic understanding of both environmental and human factors influencing the species' conservation the study area.

2.3 Data collection

2.3.1 Occurrence data:
Field surveys involved capturing frogs using dip nets and minnow traps, pitfalls with drift fences and visual encounter surveys. These methods are fully described in Larsen (2016). Sampling sites were selected based on historical records and areas likely to support *Xenopus ruwenzoriensis* populations. Additionally, two georeferenced occurrence records were downloaded from the Global Biodiversity Information Facility (GBIF) after removing records with missing coordinates and duplicates.

2.3.2 Climate data:
Climate data and elevation data were obtained from Worldclim 2.1 (https://www.worldclim.org/). The datasets included current climate layers (1960–2000) and downscaled CMIP6 projections for 2021–2040 (near future) and 2041–2060 (mid-future) at 2.5-arc-minute resolution (Fick & Hijmans, 2017). The datasets contained nineteen bioclimatic variables (BIO1–BIO19) from which five non-collinear variables/predictors were selected together with the elevation raster. The selected predictors included; BIO1 for Annual Mean Temperature; BIO2 for Diurnal Temperature Range; BIO4 for Temperature Seasonality, BIO12 for Annual Precipitation, and BIO15 for Precipitation Seasonality. These variables are commonly used in amphibian SDMs and reflect both thermal and hydrological constraints important for *Xenopus* ecology (Rödder, 2009). Future climate data were obtained from WorldClim downscaled CMIP6 projections under: SSP2-4.5 (intermediate emissions) and SSP5-8.5 (high emissions) for two time periods (2021–2040 &2041–2060). Five General Circulation Models (ACCESS-CM2, BCC-CSM2-MR, MIROC6, CMCC-ESM2, EC-Earth3-Veg.) were used for ensemble modelling.

2.3.3 Community Perceptions
Community perceptions related to amphibian conservation were assessed in villages bordering Semuliki National Park and the Rwenzori Mountains National Park. Data were collected using Focus Group Discussions (FGDs), and household questionnaires. FGDs (6–10 participants each) captured shared views and local ecological knowledge while questionnaires were administered at household level to document individual awareness, attitudes, and perceived threats to amphibians and their habitats.

2.4 Data analysis

2.4.1 Species Distribution Modelling (SDM)
Modelling was carried out using MaxEnt v3.4.3, a widely used presence-only machine learning algorithm suitable for species with limited occurrence records (Pearson et al., 2007; Phillips et al., 2006). The model was implemented in R using the *dismo*, *raster*, and *terra* packages.

2.4.2 Prediction and Mapping
The trained MaxEnt model was projected onto current (1970–2000) climate data to generate a continuous current habitat suitability map for the Albertine Rift. Future suitability was

predicted for each GCM × SSP × period combination. Ensemble maps were derived by averaging predictions across the five GCMs for each scenario, reducing individual model uncertainty (Araújo & New, 2007). Difference maps (future minus current) were used to identify: areas of suitability gain, areas of loss, and regions remaining stable. Hotspot maps (top 10% suitability) were generated, and suitable area (km²) was estimated using cell-area calculations.

2.4.3 Analysis of Community Perception Data

Qualitative data from FGDs and interviews were summarized through manual thematic analysis, where responses were grouped into key themes such as species awareness, threats, cultural perceptions, and conservation attitudes.

Questionnaire data were analyzed using simple descriptive statistics (frequencies and percentages) to summarize levels of awareness and attitudes toward amphibian conservation.

3. Results

3.1 Field survey results

Field surveys confirmed the presence of *Xenopus ruwenzoriensis* in Semuliki National Park, where it exhibited high abundance in the slow-moving stream habitats. In contrast, no individuals were recorded during comparable survey efforts in Rwenzori Mountains National Park.

Figure 2: Field team in Rwenzori Mountains National Park (1), Researcher setting up pitfalls with a drift fence in Semuliki National Park (2), Xenopus ruenzoriensis specimen (3), Hind limb of Xenopus ruwenzoriensis showing the 4 claws as one of the identification features (4)

3.2 Current and future spatial distribution patterns of *Xenopus ruwenzoriensis* in Uganda

The species distribution model showed strong predictive performance with a mean Area Under Curve of 0.943. This suggests a high ability to discriminate suitable from unsuitable environments. Predicted suitability at known occurrence locations was high overall, with a median suitability of 0.977 and a mean of 0.838, although one GBIF record from Budongo Forest Reserve exhibited a notably low value (≈ 0.059).

The model showed that Current (1970–2000) habitat suitability is strongly concentrated in the western Albertine Rift, particularly in and around Semuliki National Park and the and the adjacent lowland forests (Fig 3)
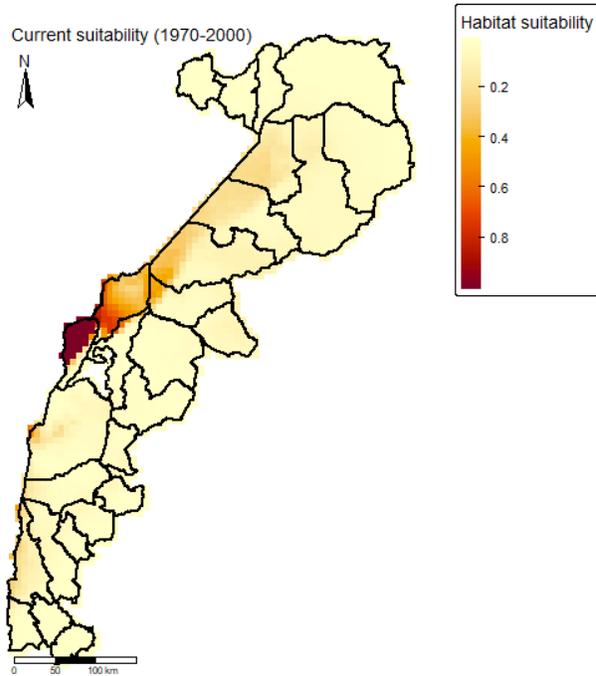
Figure 3: Current habitat suitability for *Xenopus ruwenzoriensis*

Jackknife tests identified annual precipitation (Bio12) and precipitation seasonality (Bio15) as the most important predictors, followed by elevation and temperature seasonality (Bio4). This is consistent with the species' known preference for humid, aseasonal lowland rainforest environments.

Future ensemble projections across Global Climate Models (GCMs) indicated a general increase in predicted climatic suitability under all scenarios.

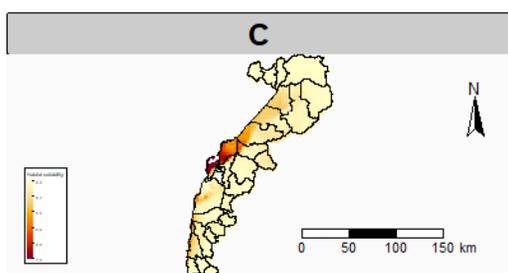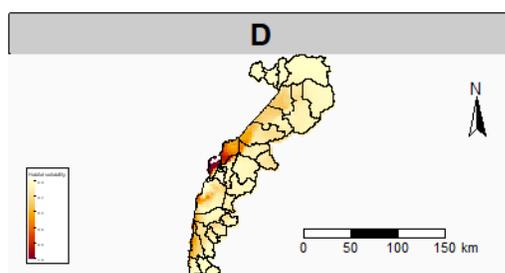SSP2-4.5 2021–2040 (A), SSP2-4.5 2041–2060 (B), SSP5-8.5 2021–2040 (C), SSP5-8.5 2041–2060 (D)
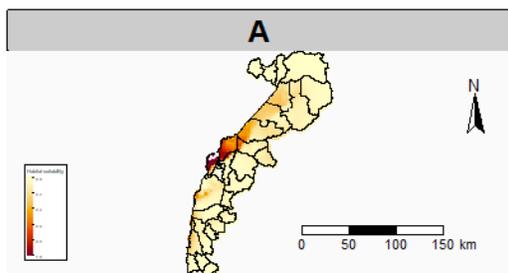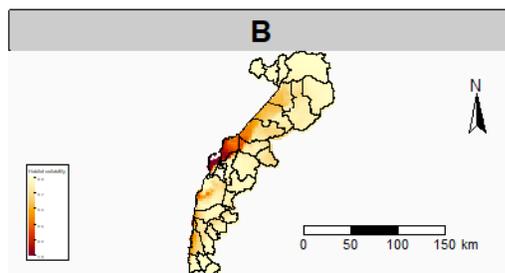
Under the higher-emissions SSP5-8.5 scenarios, minor to moderate losses were recorded. The net change under the studied scenarios is given below.

Scenario	Period	Gain (km²)	Loss (km²)	Net change (km²)	% change from current
SSP2-4.5	2021–2040	+51,163	~0	+51,163	+5,320%
SSP2-4.5	2041–2060	+51,163	~0	+51,163	+5,320%
SSP5-8.5	2021–2040	+51,142	–21	+51,121	+5,313%
SSP5-8.5	2041–2060	+50,608	–556	+50,052	+5,203%

3.3 Potential threats in the habitat where *Xenopus ruwenzoriensis* is found
    i.   **Agricultural Threats**

Majority of the occurrences were recorded within the Semuliki National Park landscape. This area is surrounded by cocoa plantations, where some farmers reported using agrichemicals and pesticides to boost yields.

The largest known population of *Xenopus ruwenzoriensis* is located within Semuliki National Park. During the survey, the species was recorded in only two communities outside the park, with very low capture rates. This indicates that the surviving population is primarily protected within the park. However, the surrounding areas are dominated by cocoa plantations, where

some farmers reported using agrichemicals and pesticides to boost yields. As these plantations border and drain into the park, the amphibians inside are at risk, especially given their sensitivity to pesticides.

ii. **Oil Manufacturing**

In Semuliki National Park, the park boundary is surrounded by several small palm oil manufacturing plants operating close to streams that flow into the park. These plants release effluents directly into the water, risking contamination of the streams and wetlands where amphibians live. There is a clear need to study whether these discharges have negative impacts on amphibian populations, particularly aquatic species.

Figure 4 Oil manufacturing plant in Makere village

iii. **Human Attitudes**

While many community members expressed willingness to protect amphibians, some groups — particularly women — held negative perceptions. When asked how they respond to amphibian encounters, some women reported killing them, either out of fear that the animals might cause harm or due to cultural beliefs linking amphibians to bad luck. Continued community sensitization is needed to foster positive attitudes and create mindset change, especially among women. In contrast, most men reported having no particular issues with amphibians and often simply ignored them.

3.4 community perceptions and sensitization on amphibian conservation

In Semuliki National Park, community sensitization was conducted using a village meetings model. Community meetings were organized in collaboration with local leaders and people were sensitized

In Rwenzori mountains National Park, an evangelism model was adopted in order to reach a wider audience. Here, sensitization of local communities was conducted in local churches on worship days in collaboration with church leaders.

During these meetings, we covered topics such as the ecological role of amphibians, threats from habitat degradation and climate change, and the importance of community involvement

in conservation efforts. Locals were also asked to suggest the role of amphibians in their culture and how best they can protect amphibians.

Figure 5: Community sensitization for communities surrounding Semuliki National Park (1&2). Community sensitization for communities surrounding Rwenzori Mountains National Park (3&4)

Communities surrounding both Semuliki and Rwenzori Mountains National Parks reported positive attitudes towards amphibian conservation. The positive attitudes mainly rooted in cultural beliefs such as the belief that frogs are not supposed to be killed. During community consultations, several participants highlighted the perceived medicinal value of amphibians beyond their ecological role. These included a traditional belief among some women that applying frog eggs (or frog spawn) to a newborn's anterior fontanelle (the soft, pulsating area on the top of a baby's skull) can help "harden" or close it more quickly. Some farmers reported that they use the sound of frogs as a natural calendar. When frogs suddenly start calling loudly at night, people know the rains are coming soon. This tells them it's the right time to prepare fields and plant seeds. The continuous calling of frogs was also reported as an acoustic indicator of environmental safety. Locals explained that an abrupt cessation of frog vocalizations often alerts them to the presence of potential disturbances or predators in the vicinity (human intruders, snakes, or larger mammals). This sudden silence prompts

heightened vigilance and precautionary measures, illustrating how communities use amphibian behaviour as an early-warning system.

Despite the many positive cultural and practical roles attributed to amphibians, perceptions were not uniformly favourable. Several respondents, particularly younger women, expressed strong aversion, describing frogs as "disgusting," or "frightening." Some community members also associated frogs with bad luck or misfortune. Additionally, frogs were also linked to witchcraft practices, and some residents reported using them as live bait in fishing. In Semuliki National Park, elderly participants recalled that certain frog species were, including *Xenopus ruwenzoriensis*, were traditionally harvested and consumed as food; however, they reported that this practice had become rare and is now largely abandoned among younger generations.

4. Discussion

The findings of this study present a nuanced picture of the conservation status of *Xenopus ruwenzoriensis*. The species distribution model results agreed with the field survey findings where the model predicted unsuitability in high altitude Rwenzori Mountains where no individuals were recorded. This is because the model associates the species with the warmer, low-elevation climates of the rift valley, not the cool, montane conditions of the high Rwenzori mountains. The high predictive accuracy of the MaxEnt model (AUC = 0.943) validates its utility for projecting distributional shifts under climate change.

Contrary to the typical narrative of climate-induced range contraction for some amphibian species, *X. ruwenzoriensis* exhibited an opposite trend. Its current restriction to the warm lowlands suggests that projected warming may render vast new areas of Uganda climatically suitable, primarily north and east of its current range. This expansion could theoretically enhance population resilience and genetic diversity. However, this optimistic projection must be heavily caveated. The model assumes unlimited dispersal and ignores critical non-climatic barriers. The extensive agricultural landscapes and human settlements between the current and future suitable areas pose formidable obstacles to colonization.

The identified threats such as agricultural chemical runoff and oil production effluent could be alarming given the species' aquatic life cycle and known sensitivity of amphibians to pollutants. The confinement of the largest population to Semuliki National Park underscores the park's critical role as a refuge but also highlights its vulnerability to edge effects and upstream pollution.

The mixed community perceptions reveal a complex socio-cultural landscape. While traditional ecological knowledge and some cultural beliefs (e.g., frogs as environmental indicators) support conservation, negative attitudes, especially fear, disgust, and associations with witchcraft present real barriers. The gendered dimension of these perceptions, with women reporting more negative views, suggests that conservation outreach must be tailored and inclusive.

5. Conclusion and recommendations
5.1 Conclusion

This study demonstrates that *Xenopus ruwenzoriensis* currently persists in a restricted range within the Albertine Rift lowlands, primarily protected within Semuliki National Park. Climate change projections indicate a substantial potential increase in climatically suitable habitat over the coming decades. However, this opportunity is counterbalanced by significant ongoing threats from habitat degradation, pollution, and mixed community perceptions on amphibians. The study therefore reveals that the future of *X. ruwenzoriensis* will likely be determined not by climate alone, but by the interplay between shifting climatic niches and the rate of habitat conversion and community engagement in its potential new range.

5.2 Recommendations
Based on the findings, the following actions are recommended:

1. **Intensify targeted surveys in Budongo CFR and other similar habitats.** The species is currently known to occur in Semuliki National Park and only one known record in Budongo CFR in Masindi district. More targeted surveys should be conducted to understand its distribution and population status within the Budongo landscape and other similar ecosystems in Uganda's Albertine region.

2. **Gender-Sensitive Community Engagement:** There is need to develop and implement targeted sensitization programs that address the specific concerns and perceptions of different community groups, particularly women. This can be done by integrating positive cultural values and traditional ecological knowledge into conservation messaging.

3. **Research and Monitoring:** There is a need to study whether discharges from oil manufacturing plants along Semuliki National Park have negative impacts on amphibian populations, particularly aquatic species. This can also be done in addition to monitoring the population trends of the species during oil manufacturing peak seasons.

6. References

Alves-Ferreira, G., Talora, D. C., Solé, M., Cervantes-López, M. J., & Heming, N. M. (2022). Unraveling global impacts of climate change on amphibians distributions: A life-history and biogeographic-based approach. In *Frontiers in Ecology and Evolution* (Vol. 10, Issue November, pp. 1–12). https://doi.org/10.3389/fevo.2022.987237

Araújo, M. B., & New, M. (2007). Ensemble forecasting of species distributions. *Trends in Ecology & Evolution*, *22*(1), 42–47.

Ayebare, S., Ponce-Reyes, R., Segan, D. ., Watson, J. E. ., Possingham, H. P., Seimon, A., & Plumptre, A. . (2013). Identifying climate resilient corridors for conservation in the Albertine Rift. *Unpublished Report by the Wildlife Conservation Society to MacArthur Foundation. Https://Www. Google. Com/Url*, *August 2014*. https://doi.org/10.13140/2.1.3219.7762

Bourke, J., Busse, K., & Böhme, W. (2018). Potential effects of climate change on the distribution of the endangered Darwin's frog. *North-Western Journal of Zoology*, *14*(2), 165–170.

Carr, J. A., Outhwaite, W. E., Goodman, G. L., & Foden, W. B. (2013). *Vital but vulnerable: Climate change vulnerability and human use of wildlife in Africa 's Albertine Rift. Occasional Paper of the IUCN Species Survival Commission.* (Issue 48, p. 244).

Chen1, X., He2, S., & Ling3, K. (2022). The impacts of climate change on amphibian distribution. *Francis Academic Press, UK, GEC 95-12*, 148–154. https://doi.org/10.25236/gemfe.2022.019

Fick, S. E., & Hijmans, R. J. (2017). WorldClim 2: new 1-km spatial resolution climate surfaces for global land areas. *International Journal of Climatology*, *37*(12), 4302–4315.

IUCN SSC Amphibian Specialist Group. (2014). Xenopus ruwenzoriensis , Uganda Clawed Frog. *The IUCN Red List of Threatened Species*, *8235*.

IUCN SSC Amphibian Specialist Group. (2023). *State of the World's Amphibians: The Second Global Amphibian Assessment*.

Kanyamibwa, S. (2013). Albertine Rift Conservation Status Report. *ARCOS Network*, *1*, 1–103.

Larsen, T. H. (2016). Core standardized methods for rapid biological field assessment. In *Conservation International* (Issue June). www.conservation.org

Lawler, J. J., Shafer, S. L., & Blaustein, A. R. (2010). Projected climate impacts for the amphibians of the western hemisphere. *Conservation Biology*, *24*(1), 38–50. https://doi.org/10.1111/j.1523-1739.2009.01403.x

Masudi, F., Kusamba, Z. C., Mlungu, A. M., Mizani, C. D., Katuala, P., Banda, G., Mbalitini, S. G., Ewango, C., Crispin, G., Tungaluna, G., & Akaibe, B. D. (2019). Note on the Amphibians and Reptiles of the Mungbwalu (Ituri Province) and Mutwanga (Province

of North-Kivu) in DRC. *American Journal of Zoology*, *2*(2), 18–27.

Pearson, R. G., Raxworthy, C. J., Nakamura, M., & Townsend Peterson, A. (2007). Predicting species distributions from small numbers of occurrence records: a test case using cryptic geckos in Madagascar. *Journal of Biogeography*, *34*(1), 102–117.

Phillips, S. J., Anderson, R. P., & Schapire, R. E. (2006). Maximum entropy modeling of species geographic distributions. *Ecological Modelling*, *190*(3–4), 231–259.

Plumptre, A. J., Ayebare, S., Pomeroy, D., Tushabe, H., Nangendo, G., Mugabe, H., Kirunda, B., & Nampindo, S. (2017). *Conserving Uganda's biodiversity: Identifying critical sites for threatened species. Unpublished report to USAID and Ministry of Tourism, Wildlife and Antiquities. September*, 25. https://uganda.wcs.org/DesktopModules/Bring2mind/DMX/Download.aspx?Command=Core_Download&EntryId=33953&language=en-US&PortalId=141&TabId=7097

Reumer, J. W. F. (1986). Note on the taxonomic status of Xenopus ruwenzoriensis (Pipidae, Amphibia). *Revue Suisse de Zoologie.*, *93*(December), 641–645. https://doi.org/10.5962/bhl.part.79503

Riyaz Ansari, M., Rahim, K., Bhoje, R., Bhosale, S., College of Engineering, M., & Mumbai, N. (2022). a Study on Research Design and Its Types. *International Research Journal of Engineering and Technology (IRJET)*, *09*(07), 1132–1135.

Rödder, D. (2009). *How to predict the future? On niches and potential distributions of amphibians and reptiles in a changing climate*. Universitäts-und Landesbibliothek Bonn.

Sammut, B., Marcuz, A., & Du Pasquier, L. (2002). The fate of duplicated major histocompatibility complex class la genes in a dodecaploid amphibian, Xenopus ruwenzoriensis. *European Journal of Immunology*, *32*(6), 1593–1604. https://doi.org/10.1002/1521-4141(200206)32:6<1593::AID-IMMU1593>3.0.CO;2-6

Schmid, M., Evans, B. J., & Bogart, J. P. (2015). Polyploidy in Amphibia. In *Cytogenetic and Genome Research* (Vol. 145, Issues 3–4, pp. 315–330). https://doi.org/10.1159/000431388

Steigerwald, E. (2021). *Impacts of climate change on amphibians* (Issue October).

Vasconcelos, T. S., Do Nascimento, B. T. M., & Prado, V. H. M. (2018). Expected impacts of climate change threaten the anuran diversity in the Brazilian hotspots. *International Journal of Business Innovation and Research*, *8*(16), 7894–7906. https://doi.org/10.1002/ece3.4357