Mapping for Climate Resilience:
Oruchinga Refugee Settlement

August 2016

Empowered lives.
Resilient nations.

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Overview

Uganda is home to more than 665,000 refugees, the third-largest refugee-hosting country in Africa. The country has progressive refugee and asylum policies, that support refugees and accord them the same access to social services as nationals, in addition to the allocation of land to support self-reliance within refugee settlements.

Refugee settlement planning and management requires careful consideration of the many challenges that may arise when delivering services and supporting such vulnerable communities sustainably and over long time periods. Service delivery, land management and conflict resolution require clear information and geospatial data that are often missing or very poor.

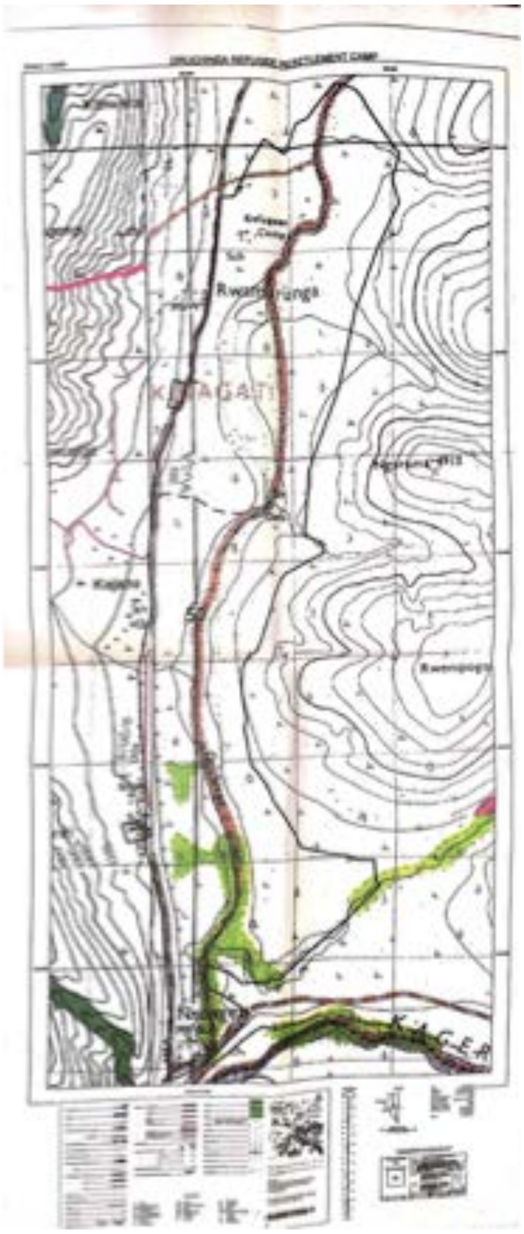
A baseline mapping exercise can inform settlements by using newly collected, current data. By updating existing maps and providing modern geospatial information, development planning, land utilization and service delivery can be enhanced.

The United Nations Development Programme (UNDP) in collaboration with the United Nations High Commissioner for Refugees (UNHCR) in support of the Office of the Prime Minister, developed the first-ever very high resolution refugee settlement map for Oruchinga Refugee Settlement. This is a first step towards integrating climate risk management into planning and decision making.

Preliminary analysis of the data shows extensive and irreversible damage of soils from on-going water erosion and sand mining. Health care accessibility is fair, with good accessibility to schools (primary and secondary). Future analysis may include accessibility to clean water. Further engagement of both the refugee and host community in planning is essential. The data presented here aims to inform the community, and its stakeholders, in planning and resource management.

1. Introduction

"Quantifying risk and expected future losses is a key step in any disaster risk reduction program. Also the outputs and scenarios of a risk assessment contribute to structuring overall risk reduction policies and planning. Geospatial risk assessment can be performed with GIS tools and techniques which can not only quantify risk but also identify the locations in need of risk reduction measures. The role of GIS doesn't stop there; in the immediate aftermath of a disaster satellite based rapid response analysis enables the emergency response agencies to perform in a better and coordinated way." (unitar.org)



Geospatial information has been used widely in city planning, service delivery, health care access planning, and natural resource management. When these data are *captured, stored, and analyzed in a geospatial information system (GIS)* they can support implementing coherent disaster risk reduction (DRR) activities at regional, national and local scales supporting climate resilient development.

To this end, baseline mapping of Oruchinga refugee settlement was undertaken to take advantage of GIS technology in providing very high quality, spatially explicit data needed to support climate and disaster risk assessment and reduction for both the refugee and host community in Oruchinga. Prior to this mapping spatially disaggregated information was barely available for the settlement except for a terrain map which was created in the early 1960's when the settlement was established (Figure 1). The data displayed in Figure 1 are in an inaccessible format for geospatial analysis and or querying and was barely used to inform decision making, also because the data were 50 years out-of-date.

Baseline mapping was carried out as part of UNDP's Integrated Climate Risk Management Programme (ICRMP) funded by the Government of Sweden to address this gap. ICRMP supports the integration of climate resilient approaches into existing livelihood activities in Oruchinga.

2. Location and Geography

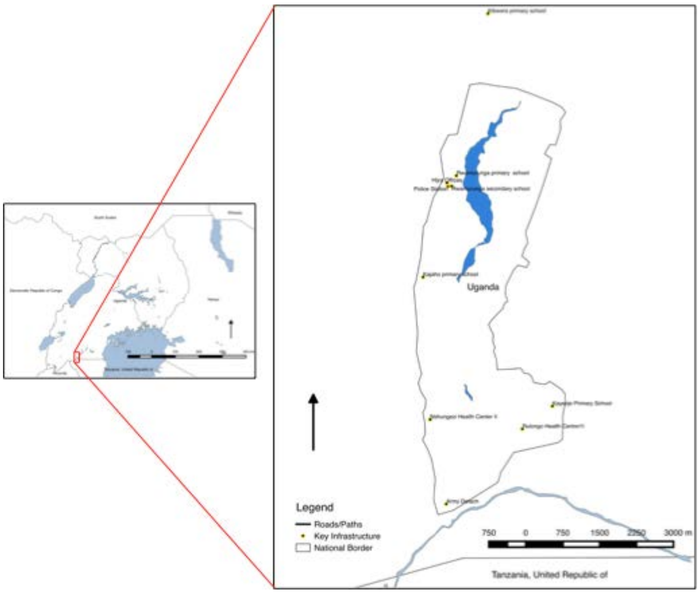


Figure 2. Location of the Oruchinga Refugee Settlement located in Isingiro district in southwestern Uganda near the Uganda/Tanzania border

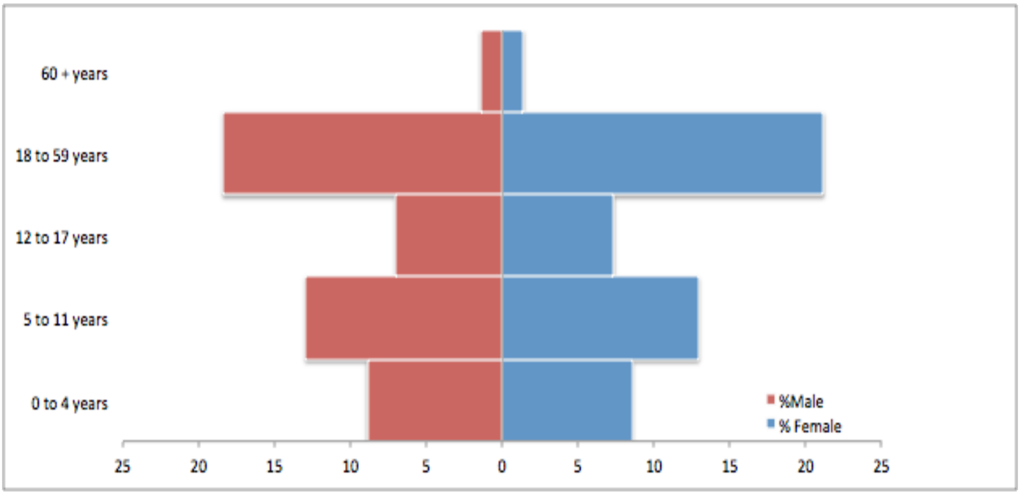


Figure 3. Population pyramid for the Oruchinga refugee settlement. 40% of the population is in the productive age group 18 to 59 years, while the remaining 60% are dependents.

The Oruchinga Refugee Settlement covers an area of approximately 8 km^2 and is located in southwestern Uganda in Isigiro district bordering Tanzania to the south (Figure 2). The refugee settlement was established in 1959 and officially recognized in 1961 through the Uganda Gazette General Notice No. 1433. The current total population is 6,289 people of concern. About 40% of the refugees are within the productive age group of 18 to 59 years, however the remaining 60% of the population falls in the dependent age groups 0 to 4 (17%), 5 to 11 (26%), 12 to 17 (14%) and 60+ (3%) (Figure 3) (source data: UNHCR, January 2016).

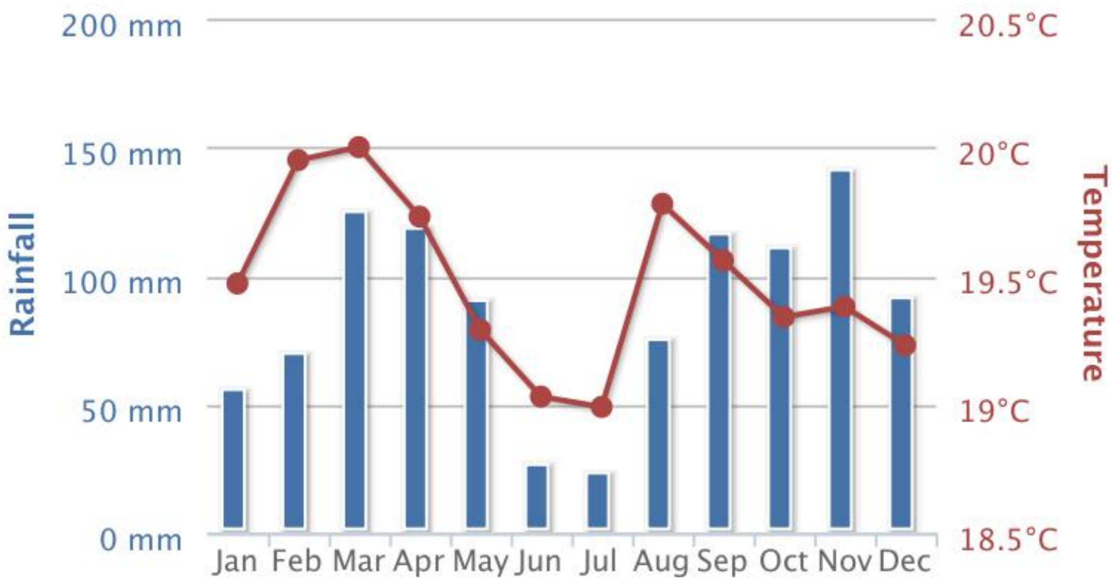


Figure 4. Average monthly rainfall and temperature in Oruchinga (Source: World Bank Climate Knowledge Portal)

Isingiro, the broader region surrounding Oruchinga, has a warm and temperate climate. Based on the 50-year climate data, rainfall in Ishingiro is significant, with precipitation occurring even during the driest months (June and July). Average annual temperature is 15.6 °C and about 1,106 mm of precipitation falls annually with 2 peak rainfall seasons, January to May and August to December (Figure 4).

3. Methodology

Baseline mapping of the Oruchinga Refugee Settlement was carried out using a fixed-wing unmanned aerial vehicle with an RGB camera. The mapping exercise covered 17 km^2, resulting in more than 1,200 individual aerial photographs covering the settlement and surrounding areas. The individual photographs were stitched together to derive a single geo-referenced ortho-photomosaic of the settlement. A three-dimensional digital surface model was derived from the overlapping aerial photographs using photogrammetry. The data were used for calculating the potential for soil erosion and for a first analysis of the potential flood damage in the settlement area. The data will serve as input to further hydrological and soil analysis such as flood risk mapping, irrigation potential from the nearby reservoir and for soil type mapping.

Mapping key infrastructure and community assets including schools and health centres was done concomitantly using the Open Data Kit (ODK) tool. The ortho-photomosaic was analysed to identify key land use classes, potential flood damage, and/erosion extent. Homes and access roads were also digitized.

During July 2016, a participatory community mapping event was organized with the Oruchinga refugee community. The mapping exercise gathered knowledge from the participants on the quality of resources, assets and infrastructures available to them. The ortho-photomosaic deepened the community's understanding of the resource quality and accessibility. The exercise also served as an opportunity for the community to discuss environmental issues that affect their day to day lives as well as access to these resources. The ortho-photomosaic enabled easy mapping to document community assets including recreational facilities.

The soil erosion potential for the Oruchinga landscape was calculated using the Universal Soil Loss Equation (USLE) (Wischmeier and Smith, 1978). This widely used approach uses a mathematical model describing soil erosion processes and estimating the risk of soil loss from water erosion. The model uses as input the annual soil loss rate, soil erodibility factor, rainfall factor, slope steepness/length factor and the land cover factor calculated from a digital elevation model, remote sensing imagery and mean annual rainfall. Here we used spectral information and 3D-terrain data derived from the UAV ortho-photomosaic and digital surface model.

All geospatial data were organized and analysed in a Geographic Information System (GIS). The GIS enabled integration of the various data sets, analysis of their spatial components, and model possible scenarios. These data will continue to support interdisciplinary research, planning and development of the settlement.

4. Preliminary Findings

4.1 Land use

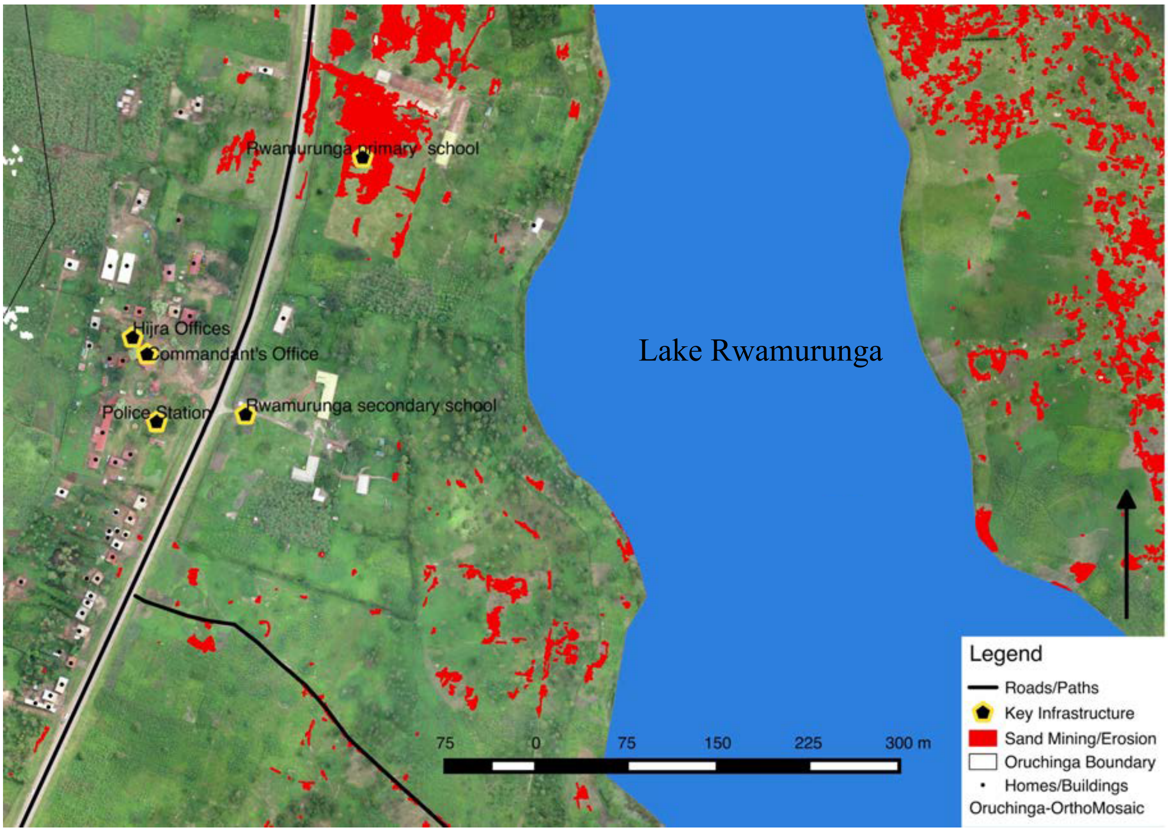
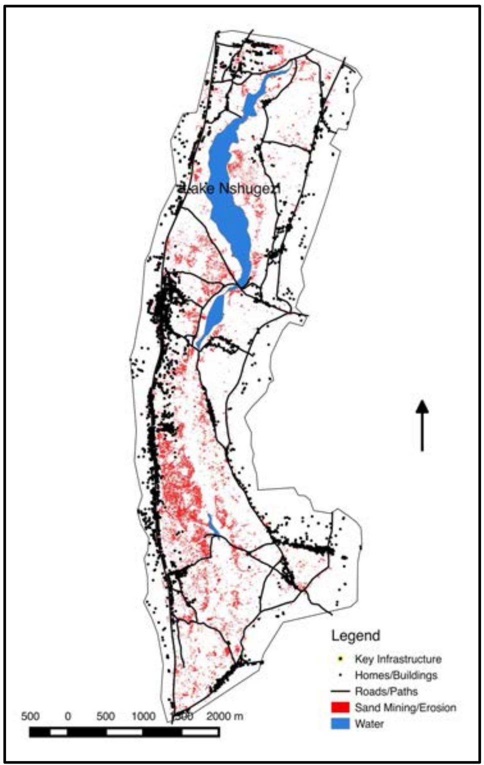


Figure 5. Location of Oruchinga Refugee Settlement headquarters key assets e.g. Rwamurunga primary and secondary school, physical features including Lake Nshugezi (blue), areas that have been eroded or sand mined (red) and buildings/houses (black dots)

Agriculture is the dominant land use in the Oruchinga. All refugee families are allocated an acre of land on which they grow crops. The major crops grown are maize, beans, bananas, and sorghum. Livelihood alternatives are very few and include fishing, mining and very few own small shops. Arable land is estimated at 60%[1] excluding areas that have been mined heavily.

Houses are concentrated along the main road to Mbarara bordering the designated area. Using the orthomosaic, over 2,900 buildings were digitized, the majority of which are located along the main road to Mbarara or paths crossing the settlement (Figure 5).

4.2 Sand mining



Extensive and irreversible land degradation is occurring due to increasing demand for sand for construction of buildings. The current extent indicates that mining is being carried out with no attention to the negative environmental impacts. Mining sand within the settlement is cheap and easy to access and extract with very little benefit to the refugee community.

Results from field observations showed that sand mining is significantly reducing farmland and grazing land. It is evident that mining is taking place on arable land and once pits are dug, crops cannot be grown anymore. Classification results indicate that most of the mining is concentrated in the southern parts of the settlement and preliminary quantification puts sand mining at 9.5% or 1.1km^2 of the mapped area (12 km^2).

Feature	Area (sq. km)	Percent
Total Area Mapped	11.8693	100
Sand Mining/ Erosion	1.1271	9.50%

Figure 6. Current extent of sand mining and erosion in Oruchinga

Sand mining is also facilitating and compounding erosion effects from heavy precipitation events that weaken raised roads. Access roads crossing the settlement have been weakened and there have been reports of deaths due to deep trenches dug to extract sand that collapse occasionally.

Sand mining not only erodes the topsoil necessary for crop growing but it also leads to degradation of rivers and affects river biota including fish. Figure 7 below shows the severity in mining and erosion near Lake Nshugezi where land has been rendered unusable.

[1] Estimate to be updated after validation

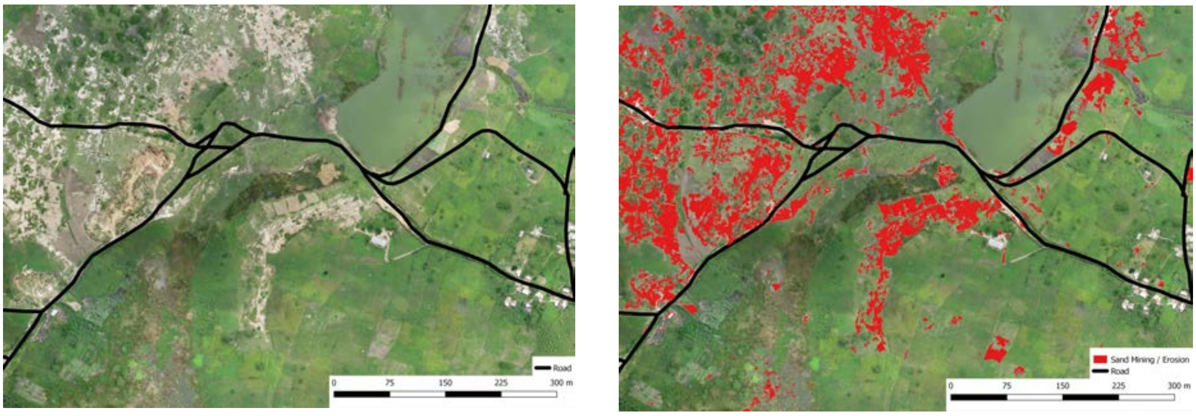


Figure 7. Severity in mining and erosion near Lake Nshugezi

Sand excavation pits are destroying the landscape by leaving behind deep and unsafe trenches. Some of the pits hold stagnant water and form breeding grounds for mosquitos. Figure 8 below depicts a pit where sand has been mined showing the severity of the damage on the landscape.

Figure 8. An open sand mining pit in Oruchinga Refugee Settlement

4.3 Flooding

Flood risk is minor outside the central depression running along the north-south axis, enclosing a small stream, a reservoir and several wetlands. A flood simulation model indicates potential flooding risk in the lower part of the central depression assuming a blocking of drainage into the Kagera River which could be caused by damming of the narrow outlet or by an increased water level in the river.

Figure 9. Flooding potential after extreme rainfall and blocked drainage into the Kagera river.

4.4 Soil erosion potential

High-quality soils for agriculture of sufficient depth are critical for maintaining the livelihoods of refugee families in the settlement, who largely depend on farming with their only alternative to rely on government support and food-aid. The predominant threats to soils in the Ourchinga area are both sand mining and soil erosion. Once the surface and subsoil horizons are lost, and the substratum or bedrock are exposed, it can take many decades or more for new soil to develop, resulting in a near-permanent loss for the current generation of farmers.

The results indicate several hotspots of areas with high soil erosion potential, focused along the western shore of the reservoir, the lower slopes along the central depression and in the South. Remarkably sand mining, which has the same devastating effects as advanced soil erosion, predominantly occurs in areas less prone to soil erosion, compounding and heightening the overall risk of permanent loss of soil and agricultural productivity in Oruchinga (Figure 10).

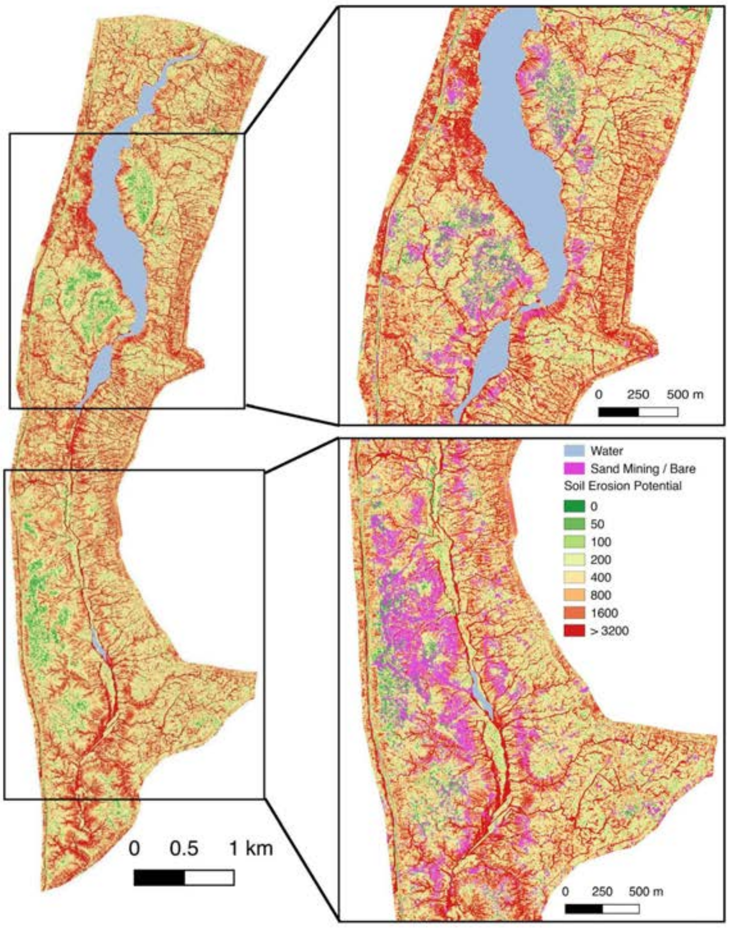


Figure 10. Soil erosion potential (units ton/acre/year) is compounded by sand mining in Oruchinga.

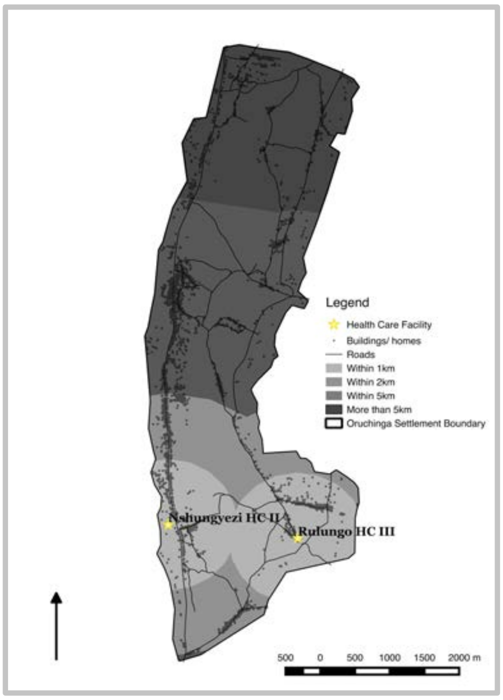
5. Access to Basic Services

5.1 Access to healthcare

We evaluated the geographical equity in health service provision and management within the Oruchinga settlement. Figure 11 below shows the catchment areas of both Rulungo Health Centre III and Nshungyezi Health Centre II. Both health centres accessible to the refugees are located in the southern half of the settlement. Access to Rulongo Health Centre is often interrupted by flooding events that wash away access bridges. Based on the mapping results (Figure 11) only 24% of the buildings/houses are located within 1 km from the two health centres and 17% at an euclidean (straight line) distance of 5 or more kilometres away.

The closest referral hospital is Mbarara Regional Hospital located more than 50km from the settlement.

The community mapping exercises highlighted their key concerns, especially poor accessibility for villages from the northern parts of the settlement. In addition to travel times, insufficiency of facilities including very the number of medical staff and limited medical supplies were highlighted.



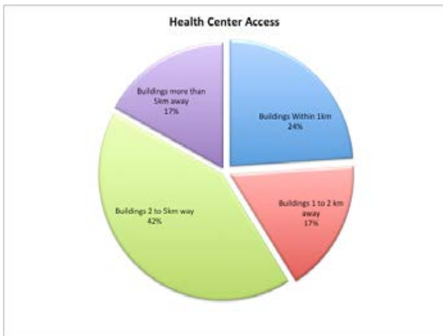
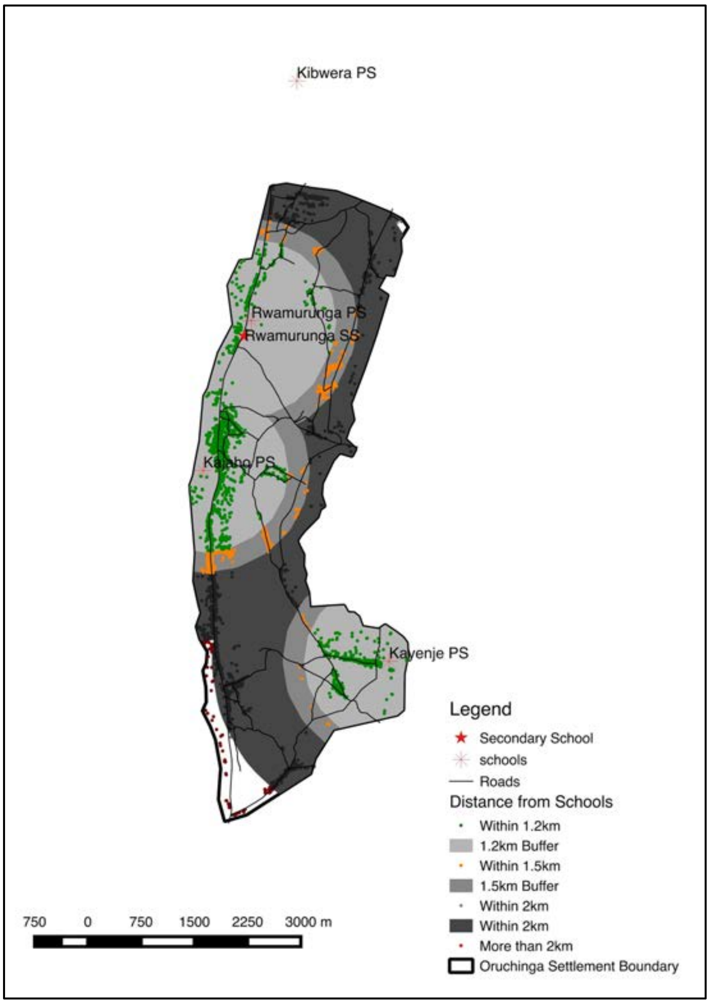


Figure 11. [Left]: Catchment areas for Rulungo Health Centre III and Nsuhgezi Health Centre II, [Top right]: Summary of accessibility based on euclidean distance from the 2 health centres and [Bottom right]: A UAV image of Rulungo Health Centre II

5.2 Access to education

According to (McDonald,2008) the typical walking rate for school-aged children is about 4.3km per hour (or 2.1km per 30 minute-period) and children are likely not to walk further than 2.1km to or from school. Within Oruchinga, 97% of houses/buildings are within 2.6km of a primary school hence, overall accessibility is high. However, the community noted that the quality of education is compromised by overcrowding in classrooms as well as the fact that there is only one secondary school serving an estimated 800 (ages 12 to 17 years) students.



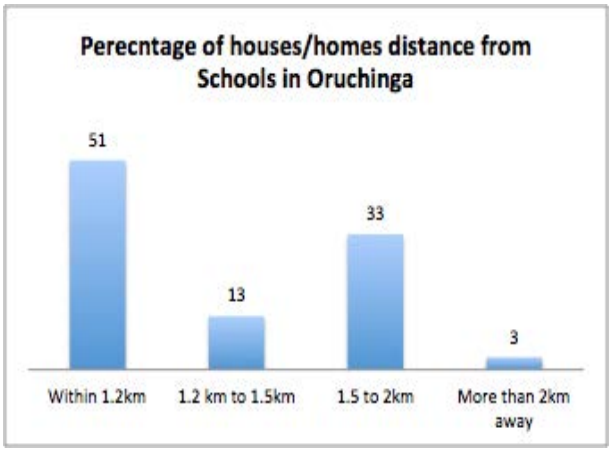


Figure 12. [Left]: Distance calculation of homes/building from the 4 main schools located within or close to Oruchinga settlement including; Rwamurunga, Kayenje, Kajaho and Kibwera Primary schools and Ramurunga Secondary School, [Top right]: Pupils from Rwamurunga Primary School having fun during one of the UAV flights and [Bottom right]: Percent of homes distance based on euclidean distance from schools

6. Summary and Recommendations

i. Key infrastructures within the settlement including access roads and walking paths was mapped. This information is only a starting point before attempting to address the full range of engineering, operational, and maintenance practices that could increase the resilience of transportation assets in the settlement.

ii. Sand mining in Oruchinga is already causing serious ecological impacts on the refugee community including land degradation, water pollution and destruction of the landscape inevitably compromising the resilience of the community. Controlling / regulating sand mining in the settlement and establish a land-zoning system, which restricts any future mining to appropriate areas without jeopardizing farm land, is recommended.

iii. Sand mining is weakening the foundation of access roads. Currently motorized transport along access roads is cumbersome. Structural resilience should be considered while developing or maintaining these roads e.g. the likelihood of bridges being washed away.

iv. Mapping all bridges as well as their quality and operating state is recommended. By combining the road network information, bridges and hydrological data (rivers and lakes) vulnerability assessments can be undertaken and determine engineering and design requirements for resilient infrastructure.

v. This analysis also hints at the need to put in place an interactive, efficient and effective data management system. The GIS layers can be updated as more data become available. Given the unique setting of the settlement we recommend a climate station be installed to collect higher resolution and locally accurate climate data.

vi. Future disease outbreaks or occurrences should be documented, mapped and added to the settlement's GIS. If this is done consistently future use of the system could include analysis of environmental factors that are likely to influence the distribution of disease and to predict potential epidemics. The same system would be used to develop, adapt and implement control strategies.

vii. The resulting GIS system can also be used to better plan and improve service delivery, location of key assets such as health centres, and schools. The system would allow participation of the Oruchinga community in planning and making e.g. for expansions and/or new installations.

viii. Future land cover data can shade light on the rate of sand mining in the settlement which if uncontrolled could result in complete loss of arable land within the next 10 to 20 years. We recommend an integrated environmental assessment of the extent and rate of sand mining as a basis for management and monitoring.

ix. If no control or management measures are put in place, the impact on livelihoods including, agriculture and fishing and other infrastructure (e.g. roads and buildings) will be irreversible. Sand mining results in damaging increases in erosion, flood heights risking cropland and infrastructure.

x. The analysis revealed high soil erosion potential in large areas of currently farmed land. It is recommended to implement soil conservation strategies and conservation agriculture management techniques to prevent irreversible loss of soil loss to water erosion. It is further recommended to design and implement soil restoration measures on already degraded farmland.

xi. Continued monitoring is absolutely essential for future planning, control measures and impact assessments of land improvement and management efforts. We recommend to repeat the land cover/use mapping and assessment with UAV orthophoto-mosaics or very high resolution remote sensing imagery together with systematic field visits every 1-2 years.

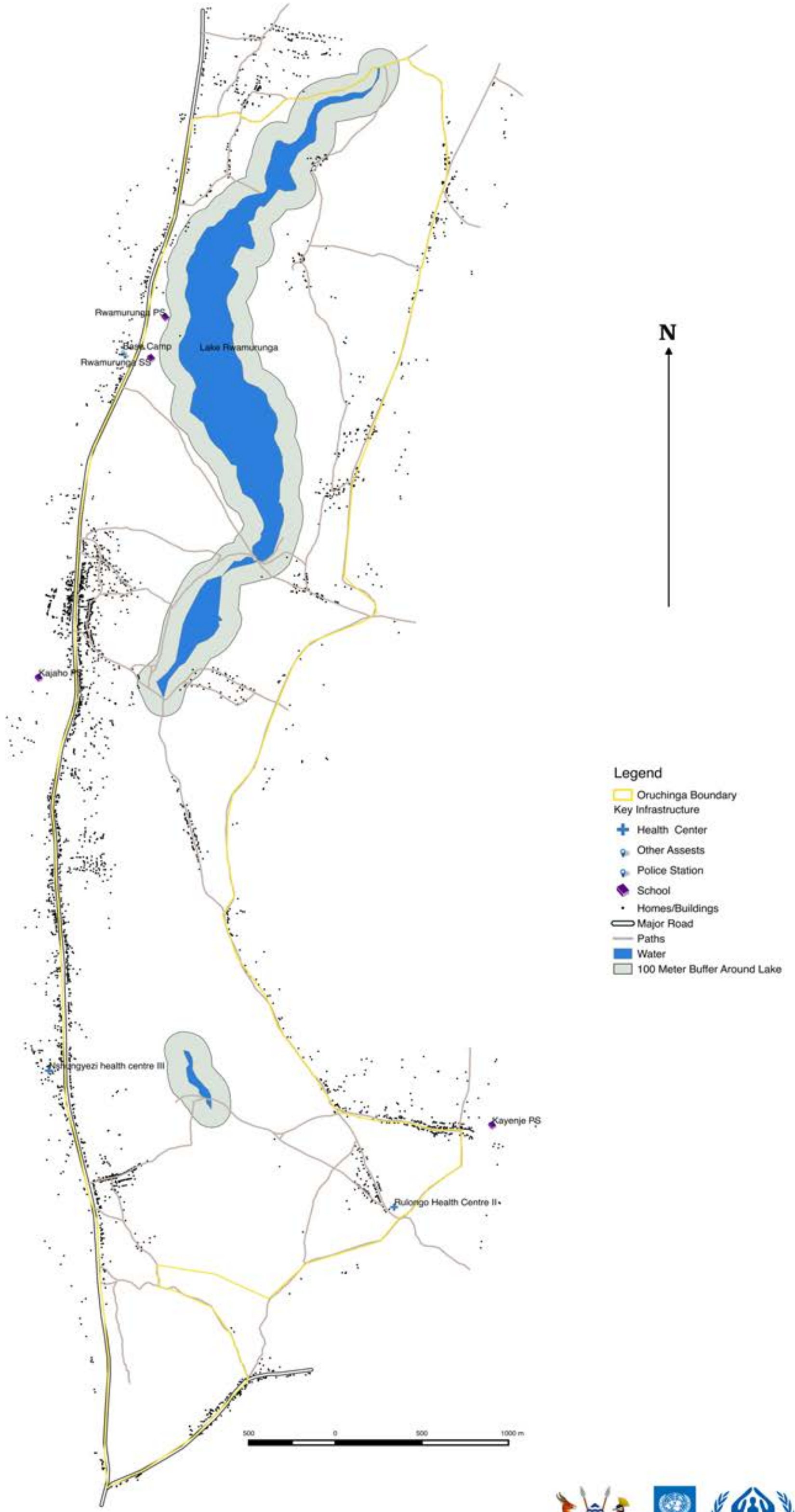
Climate projections for Uganda indicate increases in annual rainfall. According to the UNDP Country Climate Profile for Uganda, models overall project increases in the proportion of rainfall that falls in heavy events and temperature is projected to increase 1.0 to 3.1˚C by the 2060s (McSweeney 2010). The rising incidence of extreme weather including heat waves, drought, and very heavy precipitation will increasingly impact crop and livestock productivity and affect infrastructure. It is vital to plan and develop and further strengthen community resilience.

The Government of Uganda included refugee management and protection within the second National Development Plan (NDP II), through the [refugee] Settlement Transformative Agenda. This approach means Uganda has created a conducive environment for including long-term development planning into the humanitarian response for refugees and their host communities. It is critical for planning and decision making to take advantage of every feasible technological innovation that can assist improving living conditions within refugee settlements and for their respective host communities. An aware community is a resilient community and the data presented above hints at the wealth of information and knowledge that can be mined from it. Within an online and interactive GIS system, planning, management and monitoring in support of climate resilient development can be realized.

In combination with other data, including future mapping of key infrastructure and from ground surveys the basemap will continue to support strategic planning efforts to identify community strengths to enhance. Other uses may include and are not limited to:

- Conflict resolution to improve community cohesion between the refugees and host community, building and expanding on existing community strength by strengthening community based projects;
- Facilitate the refugee community's engagement and involvement in planning;
- Manage resources (water/water points, arable land);
- Identifying and increasing community capacity and resilience;
- Continued land use/cover mapping and zoning;
- Flood mapping and management; and
- Monitoring of soil erosion risk analysis and mitigation.

ORUCHINGA SETTLEMENT



In May 2016, the United Nations Development Programme (UNDP) in collaboration with the United Nations High Commissioner for Refugees (UNHCR) and in support of the Office of the Prime Minister developed the first-ever high resolution refugee settlement map in Uganda for Oruchinga Settlement. This is a first step towards integrating climate and disaster risk management into planning and decision making to support risk-informed development. This basemap was developed with technical support from Unversity of Maryland.

References

De Souza, D., 2009. Evidence-Based Approach to Decision Making: The Inclusion of GIS as Part of Ghana's Health Information Systems. *Ghana Medical Journal*, *43*(1), 1–6. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2709165/#

McSweeney, C., New, M. & Lizcano, G. 2010. UNDP Climate Change Country Profiles: Uganda. Available: http://country-profiles.geog.ox.ac.uk/ [Accessed 4 August 2016]

Wischmeier, W. H., and D. D. Smith, 1960. "A universal soil-loss equation to guide conservation farm planning." *Trans. Int. Congr. Soil Sci.,* 7th, p. 418-425.

McDonald NC., 2007. Active transportation to school: trends among U.S. schoolchildren, 1969 –2001. Am J Prev Med;32(6):509 –16.