18

Youth Engagement and Participation in Mitigating Perennial Flooding in Kampala, Uganda Using Open Geospatial Data

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Abstract

Ingraining spatial thinking for problem-solving is critical for future decision makers and leaders. We argue that the use of open geospatial data and technology makes it easier to understand the interconnections between places and many socioecological issues facing communities. This facilitates openness to adopt the methods and strategies needed to make our communities and the world at large a better place as envisaged by UN-SDG 11. This case of two informal human settlements Uganda features low-lying areas with mostly slum conditions and urban poor migrants who settled there from rural communities in search of better livelihoods. YouthMappers documented conditions of drainage systems that impact flood vulnerability. We highlight important lessons in collaborating with local humanitarian organizations to spatially conceptualize development-related activities for underprivileged communities in a context that resonates with local people.

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1 Rural to Urban Migration in Africa

Many African cities have experienced rapid population growth and by 2050, the African urban areas are projected to have an additional 950 million people to the current population of about 567 million people (OECD/SWAC 2020). This increasing trend of Africa's urban population growth presents many challenges including socioecological and sanitation problems related to exponential growth of informal human settlements or slums. Kampala is one such major African urban center that has experienced significant growth over the past few decades.

A primary driver of urban settlements is rural-urban migration, mostly youth and educated pro-

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fessionals seeking employment in commercial hubs, in search of better employment opportunities and improved living conditions. However, an increasing number of rural migrants end up in informal settlements or slums that sprung up in different parts of Kampala district including Bwaise, Kalerwe, Kireka, Lufuka, and Najjanankumbi. The slums in these areas are not very different from those in other major cities in Africa and are generally distinguished by the poor quality of housing, the poverty of the inhabitants, the lack of public and private services, and the poor integration of the inhabitants into the broader community and its opportunities (UN-Habitat 2003).

In the Kampala area, Bwaise and Kalerwe slums are the most affected by widespread flooding during heavy rainstorms because they are low lying. This is due to increased demand for land and housing which causes the urban poor to seek shelter, "homes" or "rooms," in low-lying areas close to canals. The canals often lack the capacity to handle the increasing volume of stormwater runoff from other parts of Kampala district that are on a relatively higher elevation. Such factors coupled with the poor drainage structures and poor waste collection in Kampala increase the vulnerability of the informal settlements of Bwaise and Kalerwe.

Another factor that has greatly contributed to the floods is the land cover change in these areas, especially the sprouting of new buildings which has led to the reduction of infiltration of rainfall thus increasing the amount of runoff. Whereas the increase in flood events can be attributed to the aforementioned factors, climate change has also greatly affected local communities, due to the increased intensity and frequency of unpredictable rainfall cycles (Douglas et al. 2008).

It is important to note that amidst all these challenges, residents in informal settlements rank far lower on human development indicators than other urban residents; they have more health problems, less access to education, social services, and employment, and most have very low incomes. Residents lack access to a clean water supply, sanitation, stormwater drainage, solid waste disposal, and many essential services.

Moreover, there is very little forward planning to address even the current problems, let alone the expected future doubling of demand. The urban poor are trapped in an informal and "illegal" world – in slums where waste is not collected, where taxes are not paid, where public services are not provided and are not well reflected on maps (UN Habitat 2003). The use of updated, timely, and reliable open-source geographic data can provide the critical information for flood resilience policy and mitigation planning (Hachmann et al. 2018).

2 Urban Flood Mapping of Informal Settlements

The main aim of our community flood mapping exercise was to showcase the potential of using open data tools to identify and assess flood vulnerability factors in informal settlements of Bwaise and Kalerwe. The outcome of such activities will support planning and development strategies to make informal settlements in African cities more inclusive, safe, resilient, and sustainable in alignment with United Nations Sustainable Development Goal 11.

2.1 Bwaise and Kalerwe Communities

Bwaise and Kalerwe are parishes in Kampala Capital City, Uganda's capital. Both parishes are located North of Kampala city's Central Business District. Bwaise comprises Bwaise I, Bwaise II and Bwaise III. It is located in the Kawempe division sub-county and bordered by Kawempe to the north, Kyebando to the east, Mulago to the southeast, Makerere to the south, and Kasubi to the southwest. Kalerwe on the other hand is bordered by Kawempe to the north, Kyebando to the east, Makerere to the south, Bwaise to the southwest, and Kazo to the west (Fig. 18.1).

Both communities are characterized as slum dwellings and represent some of the poorest areas in the city. They are also located in low-lying areas, close to major drainage channels and wetlands which makes them prone to floods and vulnerable to waterborne diseases such as cholera and typhoid.

2.2 Pre-fieldwork Preparations

The community flood mapping and data collection exercises were undertaken by YouthMappers from the GeoYouthMappers Chapter at Makerere University. A number of preparations were carried out before the data collection process ensued. Before any data collection exercise is carried out in any part of Uganda, it is important to inform local authorities about the purpose of the activity and how the data collected will be used, which in this case was the Local Council (LC) I.

To aid the data collection process, we approached Uganda Red Cross about the possibility of partnering in this endeavor. They gave a positive response. This partnership was important because most of the YouthMappers from Makerere University were not familiar with the people and the living conditions in the slum areas, Bwaise and Kalerwe. Uganda Red Cross volunteers facilitated a briefing session on the morning of the fieldwork. They briefed the YouthMappers about the seven core principles of Red Cross humanitarian work, and the symbolism that people attach to anyone wearing the Red Cross jacket (Figs. 18.2 and 18.3). Working with the Ugandan Red Cross facilitated interactions with residents in the target communities of Bwaise and Kalerwe. Community members are already familiar with the humanitarian activities of the Uganda Red Cross in their communities. As a result, the authorities and the residents were more receptive and willing to participate in the data collection exercise led by YouthMappers.

Fig. 18.1 A map of the study area shows Bwaise and Kalerwe informal settlements

2.3 Data Collection

The data collection exercise was executed by a group of YouthMappers volunteers from the GeoYouthMappers Chapter and three volunteers from Uganda Red Cross. In all, there were 27 participants, and they were divided into 9 teams. The teams started by collecting data in Bwaise and later, in Kalerwe (Fig. 18.4).

Fig. 18.2 The mapping team is briefed by a Uganda Red Cross Volunteer

In both places, the teams spread out to different parts of the settlement, and they also interacted with the community members who provided invaluable contextual information about the state of the drainage system, sanitation, and perennial floods in the settlements. The teams kept in touch through a coordinator from the YouthMappers group, while community leaders were given updates by the Ugandan Red Cross volunteers.

A data collection form used was created using KoBoCollect, an android-based geographic data collection app that facilitates the creation of open-source Mobile Data Collection forms in both online and offline formats (Fernanda et al. 2020; KoBoToolbox 2021). This application was used to build a 12-question survey pertaining to both rubbish dumps and drainages in the settlements (Fig. 18.5). Some of the data collected pertained to attributes such as the geographic location, vegetation close to these features, proximity to roads, and land use. At the end of the fieldwork, the student volunteers uploaded their data to the kobo server for collation and assessment.

Fig. 18.3 YouthMappers listen intently to the mobile briefing provided by partners in the Red Cross

Fig. 18.4 YouthMappers and Red Cross volunteers collect data together in the field

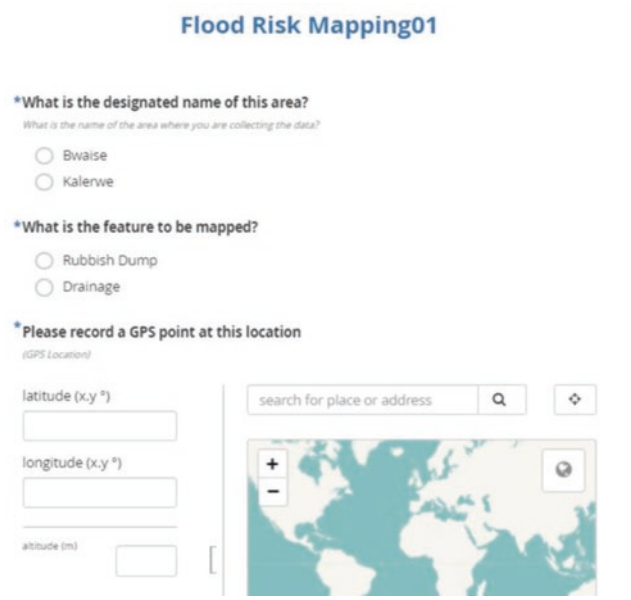

Fig. 18.5 The project utilizes a KoBoCollect data collection form

2.4 Community Mapping Results

A total of 562 data locations were collected in both settlements, 316 in Bwaise and 246 in Kalerwe. Particularly, 303 data points were located along drainage channels and 259 represent rubbish dumps in the two settlements (Fig. 18.6; Table 18.1).

Of the 167 drainage points collected in Bwaise, 26% were near the road network whereas 74% were in drainage channels; 56% of these had vegetation close to them; 35% of the drainage points had grass cover, with 52% of the points having vegetation covering about 30% of the channel (Fig. 18.7).

The rubbish dumps, on the other hand, were found both along the roads as well as inside the community. Rubbish dumps had been created in various spots all over the settlement, though in most instances, people dump their waste materials at their nearest convenient location.

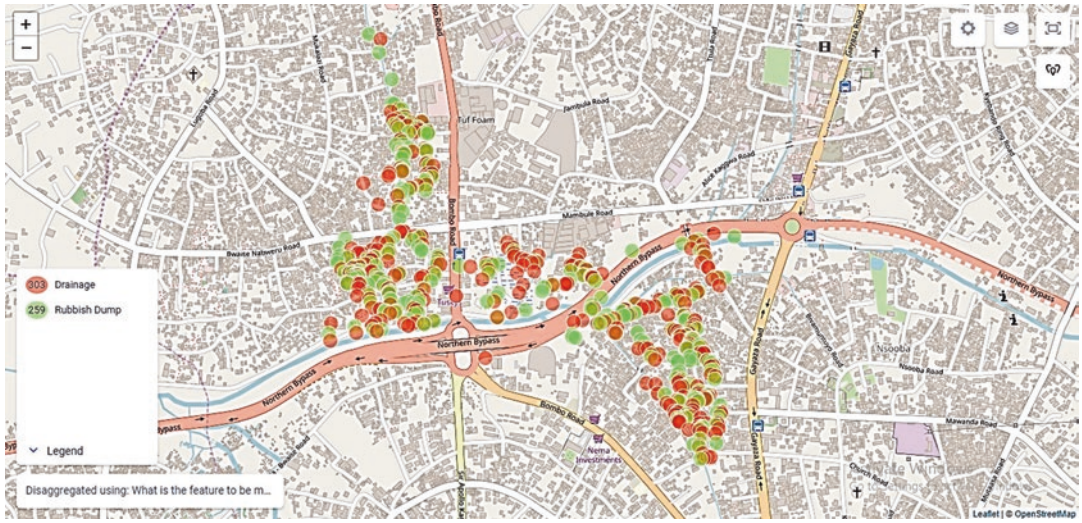

Fig. 18.6 Flood vulnerability data collected for Bwaise and Kalerwe slums are visualized on an OSM building footprint basemap

Table 18.1 Proportional distribution of data collection points

	Bwaise	Kalerwe	Total
Data points collected	316	246	562
Rubbish dumps	149	110	259
Drainage channels	167	136	303
Drainage near road	26%	41%	
Vegetation close feature	56%	46%	
Drainage with vegetation	35%	31%	
Extent of vegetation coverage (%)			
Less than 30%	52%	57%	
30–50%	33%	31%	
50–70%	16%	5%	
More than 70%	0%	7%	

In Kalerwe, 41% of the drainage points were collected along the main road, whereas 59% were collected within the community (Table 18.1). Forty-six percent were close to vegetation, also predominantly grass and 31% had vegetation covering the drainage with 57% covering about 30% of the drainage channels. The rubbish dumps in Kalerwe were found all over the community both along the roads and in the community similar to the situation in Bwaise (Figs. 18.8, 18.9, and 18.10).

3 Lessons from Fieldwork in Informal Settlements

Bwaise and Kalerwe informal settlements are the worst affected areas due to perennial flooding in Kampala district. Floods are attributed to the state of the drainage system and lowlands, poor waste disposal systems, not only in these settlements but also in Kampala city, as well as increased built-up areas resulting in more impervious areas, less infiltration, and more stormwater runoff (Chereni et al. 2020).

Fig. 18.7 A drainage canal marks a path in Bwaise

Fig. 18.8 Some drainage canals like this one in Kalerwe are fully covered by vegetation

Fig. 18.9 Rubbish is dumped indiscriminately in informal sites in Bwaise and Kalerwe

Kampala is famously known as the city of seven hills, where hilly areas are inhabited by the affluent members of the population. However, the majority of people live and work in the lowland areas of the city. Stormwater runoff from the areas of high elevation or hilly terrain is directed

Fig. 18.10 Rubbish dumps are situated very close to the drainage canals, and some are evidently blocked, leading to stagnant water

to the lowland areas such as Bwaise and Kalerwe, leaving the inhabitants vulnerable to extensive flooding and destruction of property.

Additionally, a number of wetlands in and around Kampala have been reclaimed to locate industrial projects such as factories and warehouses. Such activities have also greatly disrupted the hydrology in the area leaving no option but for the stormwater to collect faster into low-lying areas of Bwaise and Kalerwe. This condition is often exacerbated by inadequate waste disposal systems in the city.

3.1 Flood Risk from Waste Disposal in Kampala District

Despite many improvements in the sanitation and waste disposal in the Central Business District and the suburbs, there has been very little improvement in informal settlements such as Bwaise and Kalerwe despite year after year of flooding (WaterAid 2007). Large heaps of rubbish are scattered around the study area, and they are neither properly delineated nor closed off. A lot of the rubbish are either thrown into drainage channels or washed into them, causing blockages and rapid overflow during typical rainstorms. The impact of poor waste disposal, especially plastic and polythene, is very evident after rain events with the drainage channels filled with water and materials (Fig. 18.7).

Results from the fieldwork confirm the dire need for improvement in the drainage channels in Bwaise and Kalerwe. The drainage system is characterized by blocked, silted sections and presence of vegetation in the channels which makes them shallower. Some drainages have been neglected for a long period of time such that vegetation covers close to 50% of their surface area. This also greatly contributes to the difficulty of stormwater flow and increases the flood risk of the inhabitants. Whereas some efforts have been made to remove the blockages, the debris is often left alongside the channels and drainages, and they are subsequently washed back into the channels during the next rainstorm (Douglas et al. 2008).

3.2 Mitigating Perennial Flooding Using Open-Source Geospatial Data

In order to cope with perennial floods, residents have to scoop water out of their houses using troughs. In more severe cases, residents are forced to vacate their homes temporarily or per-

manently, especially during the rainy seasons. Other ways in which residents have adapted is through using flood-proofing mechanisms to reduce the impact of water by raising their houses, thickening their walls with more mud, and constructing barriers at the entrances to their houses, to mention but a few built solutions. There have also been some efforts by the members of the communities to desilt choked drainages, but this occurs less frequently.

Flooding not only affects residents' homes but also businesses in the area. In some instances, schools and shops close most of the day and the roads are impassable. Perennial flooding events usually destroy personal property as well as disrupt the livelihoods of residents in informal settlements.

Douglas et al. (2008) proposed a number of solutions to upgrade the slums such as setting up new housing for the residents and relocation, carrying out rehabilitation activities, construction of wider and deeper drainage channels, frequent desilting, setting up a proper waste disposal system and enforcing stricter flood prevention policies and urban planning codes. Solutions require decision makers to have access to up-to-date information in the form of the residents' voices through social surveys and geospatial information which shows the "what" and the "where" aspects of flood risk factors in the communities. A first important step for any mitigation will be to map all of the informal settlements in Kampala, to an acceptable degree of completeness and at a low cost. This can be realized using open geospatial tools, e.g., OpenStreetMap, which are freely available and usable by everyone.

3.3 Mapping with Local Residents of Informal Settlements

OpenStreetMap (OSM) and its many associated tools are very well suited for the collection of geolocated data. OSM is a free editable map of the world composed of data collected and created by mappers from different parts of the world. It emphasizes local knowledge and is largely community-driven providing freely available data for many purposes (OSM 2021).

The data collected during the fieldwork in Bwaise and Kalerwe was based on Kobo Collect, an open-source app which can be used together with OSM. It exemplified how citizen volunteers can contribute vital place-based data to facilitate the accurate assessment of flood vulnerability and mitigation issues in developing countries. Harnessing this geospatial technology opens up the possibilities of efficient decision-making through the use of analytical models – intuitive visualizations which create an awareness of what is happening on ground, especially in informal settlements such as Bwaise and Kalerwe. It also provides an opportunity for proper planning of the drainage system, best locations for relocation, rehabilitation initiatives, and monitoring of waste disposal. This approach allows direct engagement with residents who are suffering the flooding impacts.

4 Toward Informing SDG 11 Through Flood Mapping

The flood risk data collected by the YouthMappers volunteers from Makerere University demonstrates the importance of participatory mapping (volunteer) data to support the effort to meet Sustainable Development Goals aimed at improving the livelihood of urban communities (United Nations 2021). Making progress toward flood risk reductions in vulnerable informal settlements of Bwaise and Kalerwe in Kampala specifically addresses SDG 11 for making cities and human settlements safe, resilient, and sustainable. It also intersects directly with addressing SDG 6, whichpromotes clean water and sanitation.

In particular, SDG 11 focuses on equitable access to adequate, safe, and affordable housing; promoting sustainable and resilient buildings; ensuring sustainable human settlement planning and management; and protecting the urban poor, especially in vulnerable informal settlements. Pursuing SDG 11 will provide good grounds to achieve other sustainable development goals

such as minimizing the growth of slums and their associated environmental problems and improving health and sanitation conditions of urban areas, which are directly related to other goals, and a fundamental part of meeting basic development needs.

Overall, the flood vulnerability data collection exercise was a success and highlights the synergy in working with partners already established in the local community and who have garnered people's trust, namely, the Ugandan Red Cross volunteers, to facilitate the process. The exercise provided a vivid picture of what could be achieved if this process is further developed for a longer period of time and covers more areas other than the cases of Bwaise and Kalerwe.

This type of community-based flood vulnerability mapping achieves two main objectives that inform the SDGs. First, it provides detailed geospatial information on the locations and types of obstructions to water flow in informal settlements with limited water and sanitation infrastructure. This is useful information for flood disaster resilience planning by Kampala city planning officials. Additionally, the process of collecting data on rubbish dumps and drainages in itself helps to enlighten the residents of slum communities about the aggravated dangers of indiscriminate rubbish dumps and clogged drainages, given the low-lying nature of their communities. Hopefully, such information may help people rethink their waste disposal habits, to reduce the risk of flooding in their communities.

The results also show the value of taking social-spatial structures into consideration when drawing plans to support proper living conditions, especially in marginalized informal settlements where growth is largely driven by informal social networks and economic migrants. The flood vulnerability mapping activity in Bwaise and Kalerwe could be the genesis of a flood risk and resilience database to support planning and sustainable mitigation efforts that engage residents in marginal or informal slums settlements within Kampala and other major urban areas in developing countries. The fieldwork also provided a rare learning opportunity for the GeoYouthMappers chapter members, as most of the student volunteers had never been in a slum environment before, let alone interacted with residents of informal settlements. This is a vital social awareness and learning experience for students, many of whom could end up making policy or planning decisions that will affect the livelihoods of residents in marginal informal settlements such as Bwaise and Kalerwe. Personally, it was helpful for us to see how the Ugandan Red Cross is protective of its integrity with the people in informal settlements. That confidence made us, as outsiders, feel welcomed by the people our work aimed to support.

Still, not all challenges can be overcome, despite best intentions. One of the issues we often encountered was residents who approached us asking for help with some basic needs. Sometimes, we YouthMappers felt powerless to help and wished we had been aware of how to address some of the basic needs of residents. This perhaps could have allowed us to achieve multiple goals of community flood mapping and humanitarian assistance.

This activity highlights the necessity as well as the possibility of continual data collection efforts to mitigate perennial flooding in informal settlements such as Bwaise and Kalerwe. We aspire for this exercise to be scaled up on a broader basis for other slums in and around Kampala district, and especially places located in flood-prone areas. It is noteworthy to mention the initial success of one of the student volunteers in the data collection exercise who wrote a grant-winning proposal as part of a YouthMappers Research Fellowship, which will take this initiative from simply collecting data to performing network analysis for access to illegal dumping sites by Kampala Capital City Authority (KCCA) and flood risk analysis. We appreciate the fact that a limited activity such as this may not be sufficient to give a full picture of the state of the informal settlements. Inspired by this start, we have initiated more discussions at the project

level on this type of citizen geospatial data collection beyond Bwaise and Kalerwe to include other slums in Kampala district.

In addition to spatial data, we also hope to incorporate the temporal domain and spread over a longer period of time. Coordinating this activity with the visiting professor, student volunteers, the Red Cross Society, and local community leaders gave rise to new insights into managing the interests of different stakeholders and how to ensure that there is effective communication among them to carry out a successful community mapping exercise aimed at improving livelihoods of some of the most vulnerable urban communities.

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