Open Data Addressing Challenges Associated with Informal Settlements in the Global South

2

Ernest Ruzindana, Federica Gaspari, Erneste Ntakobangize, Chiara Ponti, Carlo Andrea Biraghi, Candan Eylül Kilsedar, Massimo Tadi, Zacharia Muindi, Peter Agenga, and Laura Mugeha

Abstract

The United Nations estimates that 3 billion people living in urban contexts will need adequate and affordable housing by 2030. We urgently need alternative perspectives and methodologies for urban development that are environmentally sustainable and inclusive of the local community. This chapter illustrates the design and results of projects carried out by YouthMappers in Rwanda, Italy, and Kenya, focused on informal settlements in the Global South and the value of geospatial data for addressing SDG 1 No Poverty and SDG 11 Sustainable Cities and Communities.

Keywords

Poverty · Informal settlements · Urbanization · Rwanda · Italy · Kenya

E. Ruzindana (✉) · E. Ntakobangize
College of Science and Technology, School of Architecture and Built Environment, University of Rwanda, Kigali, Rwanda

F. Gaspari · C. Ponti · C. A. Biraghi · C. E. Kilsedar
Department of Civil and Environmental Engineering, Politecnico di Milano, Milan, Italy
e-mail: federica.gaspari@polimi.it; chiara1.ponti@mail.polimi.it; carloandrea.biraghi@polimi.it; candaneylul.kilsedar@polimi.it

M. Tadi
Department of Architecture, Built Environment and Construction Engineering, Politecnico di Milano, Milan, Italy
e-mail: massimo.tadi@polimi.it

Z. Muindi
Map Kibera Trust, Nairobi, Kenya

P. Agenga
Department of Geography, University of Nairobi, Nairobi, Kenya

L. Mugeha
Department of Geomatics Engineering and Geospatial Information Systems, Jomo Kenyatta University of Agriculture and Technology, Juja, Kenya

P. Solís, M. Zeballos (eds.), *Open Mapping towards Sustainable Development Goals*, Sustainable Development Goals Series, https://doi.org/10.1007/978-3-031-05182-1_2

1 Introduction

The research, methods, activities, and stories captured here center the innovative and interdisciplinary work carried out by university students and faculty to address the local impact of global issues. YouthMappers, a global university consortium, has created a space for students to participate in the creation of geospatial data while positioning them not only as contributors but also as leaders with valuable local knowledge and experience. Students are making vital contributions to filling critical data gaps and, in the process, leading a movement toward social change with youth at the forefront.

We present three different experiences by local YouthMappers Chapters in Rwanda, Italy, and Kenya focusing on mapping activities within informal settlements. Crucial to the success of each activity were the partnerships created with local entities and across the YouthMappers network, the tools and platforms selected to implement projects, and the design of the mapping activities. The authors discuss the potential of approaches based on open data created collaboratively in critical geographical and social contexts.

2 Urbanization in the Global South

Nowadays, 56% of the world's population lives in urban areas, and this number is rapidly growing. The share of people living in cities is expected to reach 68% in 2050 (UN 2019), reversing the numbers of one century ago when rural settlements were predominant (71%). This growth will mainly happen in the countries where their share of the population in urban areas is lower than the world average. Countries with high population and urbanization rates often have very low values of the Human Development Index (HDI), an index calculated by combining human development aspects such as life expectancy, education, and per capita income indicators (UNDP 2020). In this ranking, 18/20 and 38/50 of the lowest positions are occupied by African countries. These are low-income countries that face serious structural obstacles to achieve sustainable development. They are highly vulnerable to economic and environmental shocks and possess low levels of human resources (Maksimov et al. 2017).

Future urbanization will likely take place in unfavourable conditions with a high probability of creating informal settlements on unclaimed land in the periphery of existing cities. The rapid diffusion of slums and other forms of informal dwellings, characterized by inadequate basic services and infrastructures, makes cities more vulnerable to disasters (Rosa 2017). Life in informal settlements is precarious as they are usually overcrowded and congested. Additionally, they lack social and community networks, present stark inequalities, have crippling social problems, are particularly vulnerable to health problems, economic shocks, and the risks related to climate change and natural disasters (Habitat 2020). Improving the living conditions of vulnerable slum dwellers is a crucial challenge for making cities and informal settlements sustainable, resilient, inclusive, and safe.

Because of their spontaneous development, informal settlements are hardly manageable by authorities and institutions, and they often do not exist in official datasets. Their complicated social and physical condition is an obstacle for gathering data about them, including geospatial data. As a result, they are usually neglected, which leads to a limited amount of information about them with low quality. The lack of data limits the awareness of the dynamics of these areas and the possibility of interventions for improvement.

Luckily, open mapping can be a valid alternative solution to support the different actors involved in planning activities around the world (Chakraborty et al. 2015). The effective use of open data sources and open software gives a significant contribution to urban studies in general and for addressing the problems of informal settlements in the Global South. Initiatives of collaborative mapping are important not only for producing up-to-date geospatial data for planning purposes but also for their participatory nature, involving local citizens in bottom-up activities that can benefit the whole community (Abbott 2003).

3 Rwanda YouthMappers Chapter Experience

Rwanda is a small landlocked territory in Central–East Africa where informal settlements exist in physically congested spaces and the quality of and access to information about them are usually limited. Facilitating open data provision and accessibility helps to bridge the limited data gap by providing an alternative source of information on open platforms (Chakraborty et al. 2015). The long-term goal of Rwanda YouthMappers, the YouthMappers chapter at the University of Rwanda, is to put Rwanda on the map. In collaboration with Kigali Geospatial Development and Research Hub (GeoDR), Rwanda YouthMappers conducted a study on the challenges associated with informal settlement upgrading in the Agatare area of Kigali city (Fig. 2.1). Open mapping was used in this project to support effective planning on behalf of the government, non-governmental organizations, and the private sector to address the problems of informal settlements in the country (Fig. 2.2).

3.1 Activities in Kigali

Informal settlements are unevenly distributed among the three districts that make up Kigali city. The study was conducted in the Agatare informal settlement area in Nyarugenge district, which is considered the home of unplanned dwellings as it is where 76% of informal settlements are located (Hitayezu et al. 2018). The area is located close to the central business district (CBD) and is dominated by limited plots, rudimentary buildings, and inferior living conditions.

Kigali GeoDR partnered with the Rwanda YouthMappers with the intention of providing up-to-date and reliable mapping responses so that the government and humanitarian actors can respond quickly to the crisis in the Agatare area (Fig. 2.3). Kigali GeoDR Hub and Rwanda YouthMappers Chapter mapped building footprints, roads, water lines, drains, rainwater collection points, markets, facilities, and power lines in OpenStreetMap (OSM) (Fig. 2.4). Data generated by this activity would support local officials' efforts to design and implement inter-

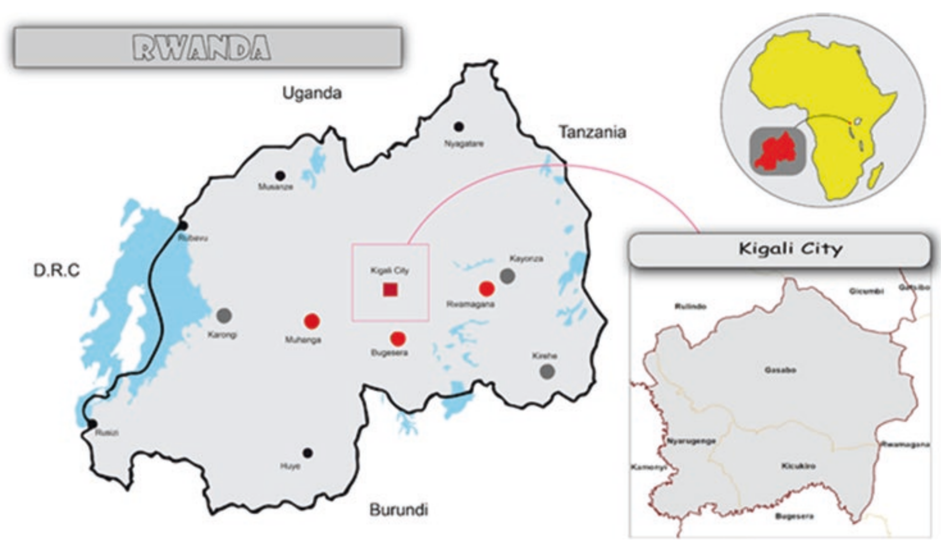

Fig. 2.1 Study area is located in Agatare area of Kigali City, Rwanda

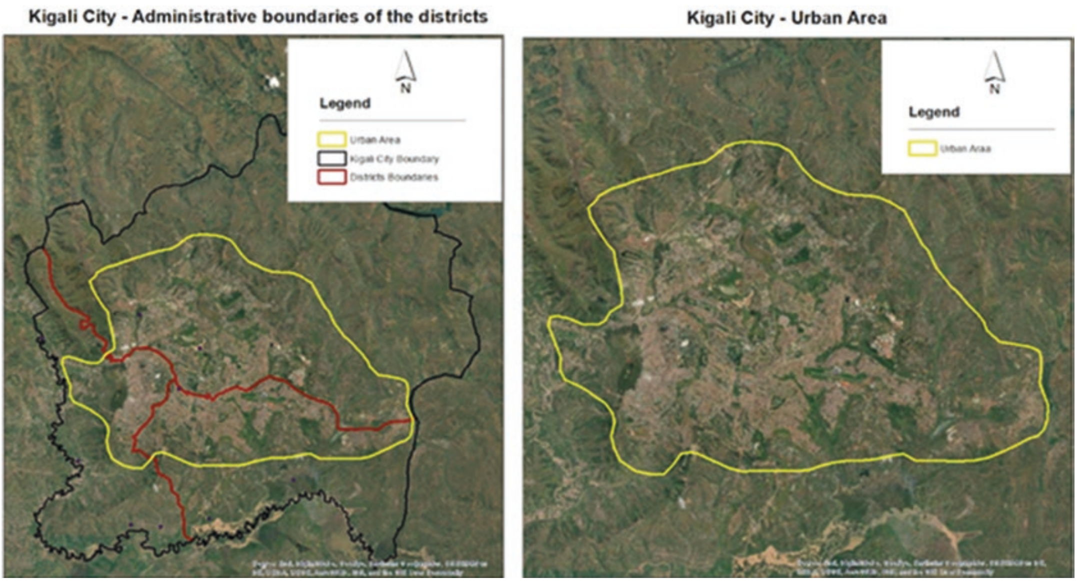

Fig. 2.2 Administrative boundaries outline the districts (red) in Kigali City, Rwanda (black), demarcating the urban settlement concentrations (yellow)

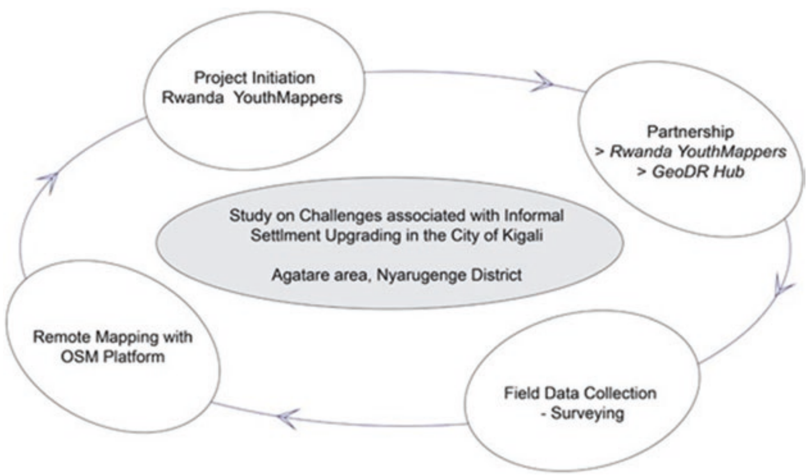

Fig. 2.3 An iterative project management cycle serves as a framework for the mapping study

ventions to make this area safe and sustainable, in the perspective of SDG 11 Sustainable Cities and Communities.

3.2 Methodology

Rwanda YouthMappers contributed to the production of geospatial data using various resources, tools, and techniques, including the application KoBoCollect downloaded on android smartphones used to collect data on the field. For remote mapping on OSM, experienced mappers used made contributions using Java OpenStreetMap editor (JOSM) and inexperienced mappers used iD editor. Finally, the data were analyzed in QGIS.

The Rwanda YouthMappers team collected data to determine the number of homes to be demolished. As part of the project, students sup-

Informal settlement in Agatare area

Fig. 2.4 Example of features mapped by the Kigali GeoDR Hub and Rwanda YouthMappers Chapter indicates building footprints, roads, and water lines in OpenStreetMap

ported the deployment of a survey for collecting non-spatial data such as the owner of the houses, the members of the households and their number, and their daily activities for survival and tried to ask them about their living conditions. This fieldwork was carried out in conjunction with office workers in order to provide accurate spatial and non-spatial data per household. This information on buildings and services within Agatare will help the city of Kigali improve decision-making related to future planning and development of the area.

The processing of data collection took six days, and the data was organized according to its use. Non-spatial data were organized to produce tables and diagrams to show the real situation and living conditions in the Agatare area. The spatial data were organized and arranged in the following way: the points data were arranged in an Excel spreadsheet before making the shapefiles; the polygons, points, and lines were imported in QGIS to produce the geodatabase that combined all kinds of data collected. Maps were produced and printed, and the final results were presented in a report.

3.3 Project Results

A total of 6.64 km of roads, streetlights, and 8.2 km of water pipelines have been mapped to serve over 15,000 residents in the Agatare area. A total of 5.3 km of drainage channels, mainly the Mpazi and Rwampala water channels and their sub-channels, have been mapped. These water channels cross 2080 residences affected by flooding and severe overflows. A total of 6.2 km of footpaths were mapped that serve over 3000 residents in their daily business activities. A total of 24.154 building footprints were mapped using JOSM and iD editor and were uploaded to OSM.

The data created through this project was used to improve roads with lighting, footpaths, electricity, water pipes, drainage, and other facilities such as public toilets, rainwater harvesting, market, and recreational facilities (Fig. 2.5). Thus, the result of the project has been assisting the city of Kigali in decision-making and enabling the upgrading of the Agatare informal settlement with the support of the World Bank. Future improvements will contribute to making the area

Fig. 2.5 Street view of data collection sites shows examples of utility poles (left) and water harvesting points (right)

safer, more resilient, and sustainable and contribute to changing the dwellers' living conditions.

4 Italian YouthMappers Chapter Experience

Italy, with an HDI of 0.88, above the threshold of very high human development, is among the first 30 countries in the ranking of 2020 (UNDP). It has a very good availability of both authoritative and volunteer data and presents very limited cases of slums. For this reason, PoliMappers (https://polimappers.github.io/), the first Italian YouthMappers chapter, since its foundation in 2016, is very active in projects located outside national borders supporting humanitarian activities in the Global South. Indeed, in the past years, the group took an active part in a wide variety of campaigns located around the world and promoted by the Humanitarian OpenStreetMap Team (HOT), Crowd2map Tanzania, and more.

Following the participation of PoliMappers in the "Architecture for Smart City" course given by Professor Massimo Tadi at Politecnico di Milano, Piacenza campus (Gaspari 2020), at the end of 2020, we took part in a new project, in partnership with IMMdesignlab (http://www.immdesignlab.com/), led by Professor Tadi.

The project is part of the master's thesis "Slums upgrading: An integrated design approach for the environmental performance and social inclusion based on IMM methodology in the border between Bogotà and Soacha, Colombia." The slum upgrading process based on strong interdisciplinarity defines a system of connected actions and strategies involving different fields of knowledge, such as architecture and urban design, systems theory, data science, energy efficiency, mobility and transportation, geospatial information analysis, people engagement strategies, water and waste management, and food policies. This case study will allow to build a benchmark development plan for slum upgrading in the framework of the SDGs. In fact, integrated modification methodology (IMM) (Tadi et al. 2020) proposes a systemic interpretation of the SDG 11 Sustainable Cities and Communities, which suggests that local-based actions are firmly linked with SDGs and their indicators and able to trigger simultaneous improvements in environmental performances, social inclusion, and urban metabolism.

In consideration of the fact that IMM is a model-based approach, it is able to define the state of a system and its performance through a rigorous qualitative and quantitative representation. It is evident that having a dataset able to support such a model is necessary for proceeding with the work. Observing the lack of informal settlement data in the authoritative datasets, the thesis proposes to adopt open and collaborative methods for data acquisition, which could then be replicated in contexts with similar characteristics.

4.1 Collaborative Activities

PoliMappers coordinated surveying and mapping activities in the study areas of Ciudad Bolívar and Cazucá, on the border of Bogotá and Soacha, developing a workflow based on the “Architecture for Smart City” course experience (Fig. 2.6). Later, San Humberto was included in the study area. Soacha is located within the metropolitan area of Bogotá and is included in the project area for Bogotá in the rest of this chapter.

In October 2020, PoliMappers officers met with the group from IMMdesignlab to define the purpose of the collaboration, training requirements, and coordination of the process for creating geo data at the ground level to perform urban diagnostic activities in the study area.

Partnering with a local NGO, TECHO Colombia became a crucial step of the process, involving their local knowledge and expertise gained through their humanitarian campaigns in the area. Indeed, their volunteers were looking for a community approach to perform street-level surveys of urban settlements, especially in the area of San Humberto. Together, by sharing personal and professional experiences, we shaped a crowdsourced paradigm structured at both local and international scales. Following a few virtual meetings, Mapillary resulted to be the most suitable tool for our purpose of capturing street-level imagery. Being already familiar with the application, PoliMappers shared solutions and suggestions to perform the survey, providing training on the use of the application for TECHO volunteers. Then, a survey plan was defined together, identifying the major roads to take photo sequences of in the study area (Fig. 2.7).

Figure 2.7 shows routes surveyed for obtaining images to identify commercial activities, housing dynamics, land use, and patterns of informality in Municipality 4 (Cazucá) and Municipality 6 (San Humberto) of Soacha and in Ciudad Bolívar in Bogotá.

The COVID-19 pandemic delayed the timing of the survey, as restrictions imposed by the local authorities did not allow free movement. In February 2021, the group of volunteers from TECHO Colombia were finally able to carry out the survey, using Mapillary installed on three mobile devices, one of which mounted in a frontal position and the other two facing the right and left sides of the road, respectively, moving by car, both to reduce the time needed to cover the established routes and to minimize safety risks (Figs. 2.8 and 2.9).

PoliMappers encountered difficulties in uploading the images due to a Mapillary server problem; the images did not appear in the application database for a long time. The initial plan

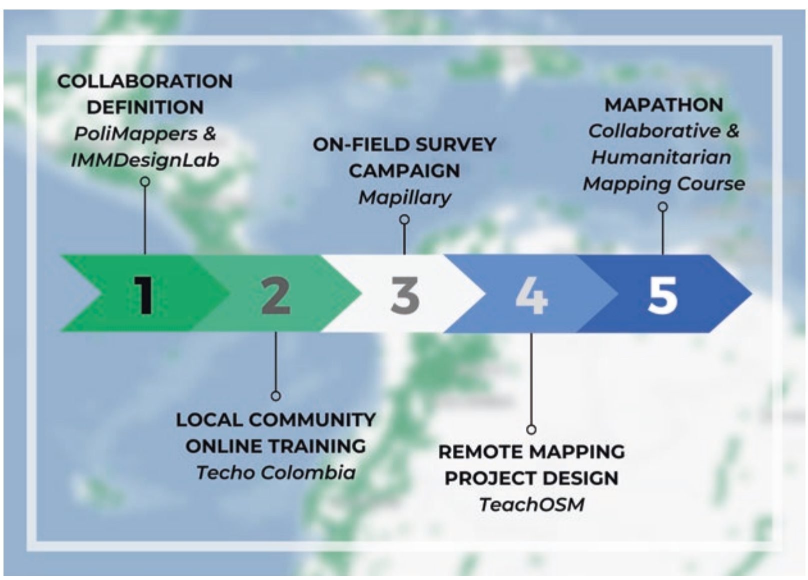

Fig. 2.6 The project workflow designed by PoliMappers serves as a framework for data collection

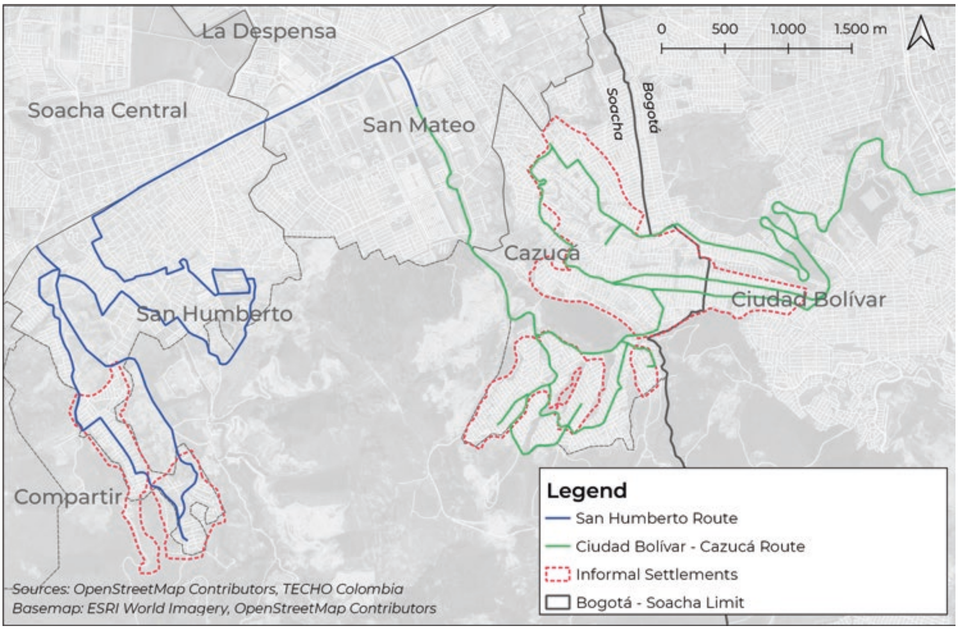

Fig. 2.7 Routes indicated serve as the basis for image collection in Cazucá and San Humberto, Bogotá, Colombia

Fig. 2.8 Front mounting of cell phone enables mobile street view image collection

Fig. 2.9 Side mounting of cell phone enables mobile street view image collection

was to use Java OpenStreetMap editor (JOSM), as it has a Mapillary plug-in that speeds up the mapping process. However, the images only appeared in the iD editor once uploaded to OSM, so this editor is used.

Following the field activities conducted by TECHO volunteers, we defined the mapathon working area on the TeachOSM platform and created Project #1270 with detailed guidelines regarding the tagging choice of shops, amenities, craft places, and healthcare points to help contributors understand the context of the mapping area.

Finally, the virtual mapathon took place on March 26, 2021, as part of the PoliMappers innovative teaching program "Collaborative and Humanitarian Mapping." The mapathon consisted of three parts:

1. An introduction to the concept and design of the slum upgrading thesis project illustrated by MSc students Maria Alejandra Rojas

Bolaño and Silvia Raviscioni, with a focus on the collaboration with TECHO Colombia
2. A tagging and mapping tutorial carried out by PoliMappers officers that gave suggestions and highlighted possible issues
3. A guided mapping session during which attendants followed the required steps to display and explore Mapillary image sequences on iD editor, evaluate the position of points of interest by using both street-level and satellite imagery, and create or edit the targeted features on OSM

The event was held on the Zoom platform and broadcasted live on the PoliMappers Twitch channel, involving participants from both Politecnico di Milano and other universities and institutions. Throughout all of its phases, the project benefited from constant support and widespread social media promotion by partner networks: YouthMappers, IMMdesignlab, TECHO Colombia, and the Colombian YouthMappers chapter at the University of Antioquia in Medellín, Semillero Geolab UdeA.

4.2 Results, Impressions, Possible Future Activities

Collaborations at various scales made it possible to reach interested people from different areas of the world. There were 39 contributors who took part in the mapping activity and created 244 changesets, in which 508 shops, 177 amenities, and 17 healthcare places were mapped (Fig. 2.10). The contributions were then validated by the PoliMappers team using the OSMCha tool, providing constructive comments in case of errors.

Most of the participants in the mapathon had OSM editing knowledge from beginner to intermediate levels. The mapping activity presented some major challenges. The lack of knowledge of the Spanish language made it difficult to find informa-

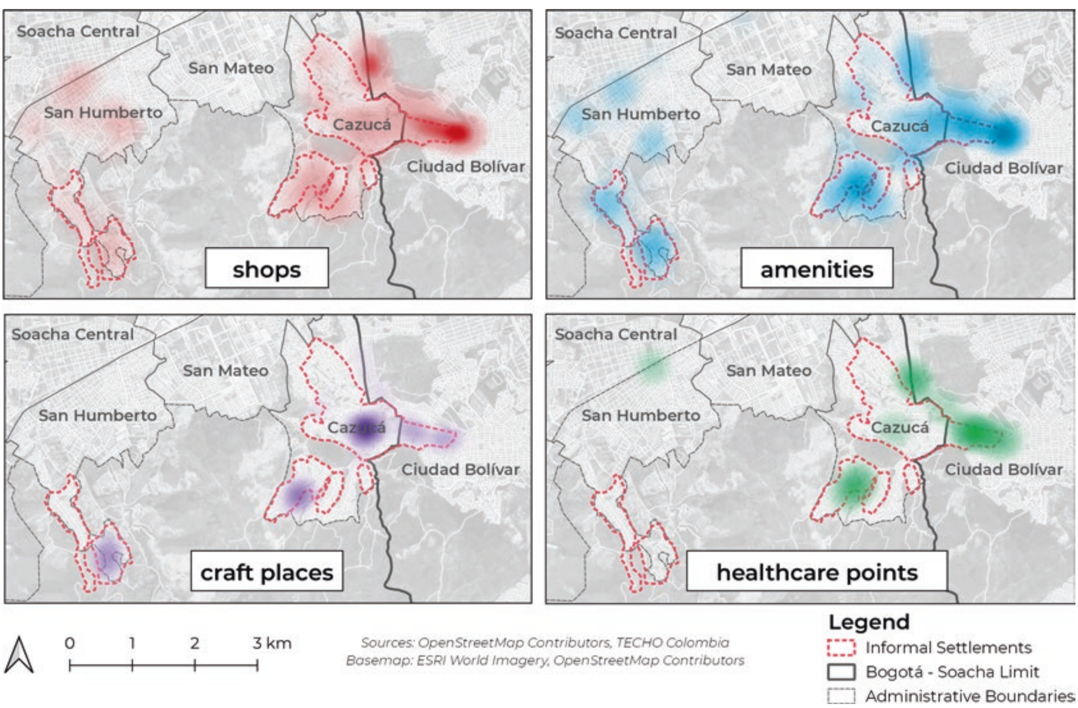

Fig. 2.10 Results of OSM attribute data collection efforts are mapped in Cazucá for shops, amenities, craft places, and healthcare points

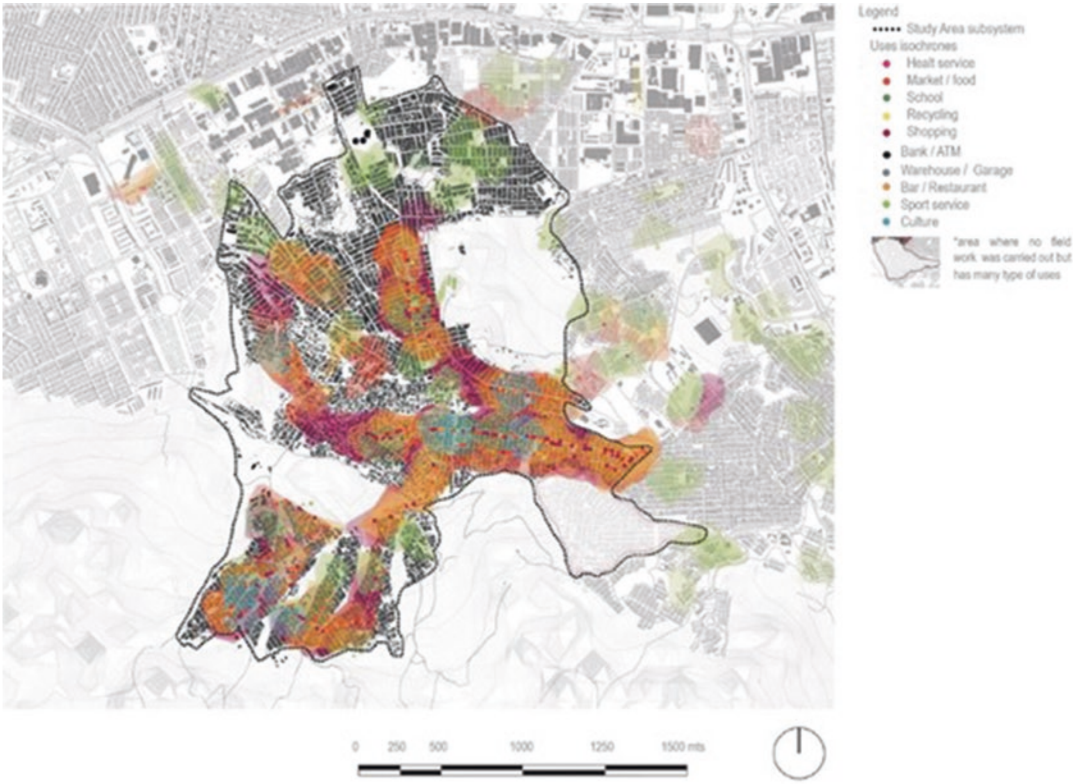

Fig. 2.11 Detailed results demonstrate OSM attribute data collection efforts by key category

tion about the use of the spaces by reading signposts. Another difficulty, which emerged during the mapathon in conversation with some of the participants, was the presence of features with characteristics specific to the study area, which were hard to tag in OSM with the available options. Using Mapillary images also required an additional effort to identify the features' correct location, combining satellite images and topographic layers.

The data gathered have been used to produce urban diagnostic maps. In particular, the analysis of IMM proximity (Fig. 2.11), accessibility, and diversity key categories was performed, enabling the design of a better slum upgrading project, relating to several SDG 11 targets including safe and affordable housing, affordable and sustainable transport systems, inclusive and sustainable urbanization, reducing the adverse effects of natural disasters, and the environmental impact of cities, among others.

Figure 2.10 shows densities of map features added by OSM contributors within the area of the mapathon. Data refers to the map edits tracked between March 26, 2021, and April 09, 2021. Dataset was harvested and parsed using overpass turbo. Fig. 2.11 depicts the urban diagnostic maps on proximity relative to key functions at the system level built on the collected data and Fig. 2.12 as a comparison between the proximity levels before and after the slum upgrading project.

The slum upgrading project using IMM methodology aimed to build a sustainable, adaptable, and scalable model for slum upgrading projects in similar contexts worldwide; it made possible to understand the need for a fully integrated strategy to solve the problems of data gathering and mapping in informal settlements as part of the project design approach.

Fig. 2.12 Urban diagnostic map results depict local proximity to services

5 Kenyan YouthMappers Chapter Experience

5.1 Partnership with Map Kibera Trust

Kibera is the largest slum in Africa. Situated in Nairobi, Kenya, Kibera is one of the most well-known, well-researched, and well-serviced slums worldwide. Despite this focus, Kibera was literally a blank spot on the map: its patterns of traffic, scarce water resources, limited medical facilities, etc., remained invisible to the outside world and residents themselves. Without the basic knowledge of the geography of Kibera, it was impossible to have an informed discussion on how to improve the lives of its residents.

In November 2009, Map Kibera produced the first complete free and open map of Kibera, thanks to local motivated young people who learned how to create maps using OSM techniques. This included surveying with handheld GPS devices, digitizing satellite imagery, and using paper-based annotations with Walking Papers. Individuals from the blossoming Nairobi tech scene helped train and make connections with the larger community and created a sustainable group of map maintainers beyond the initial three-week effort. Data consumers were consulted for their needs to help add direction to feature types collected and immediately make use of the map data. Map Kibera has grown into a complete interactive community information project.

5.2 Joint Initiatives Between Map Kibera and YouthMappers

In 2016, Map Kibera helped launch the first YouthMappers chapter in Kenya at the University of Nairobi by providing capacity-building training to new chapter members. This led to a series of joint initiatives including:

1. The mapping of water and sanitation facilities in Mathare, a slum in Nairobi, to support the initiatives of the United States Agency for International Development (USAID) in that area
2. Hosting a joint mapathon with the Young African Leaders Initiative (YALI) during the 2017 high-level meeting for data and development in Africa (ODW 2017)

3. Launching a program to provide YouthMappers members with internship opportunities to get hands-on experience in mapping informal settlements and the methodologies used in the projects

5.3 Methodology

During the national elections in Kenya, informal settlements in Kenya are most affected by election-related violence. With the then-upcoming national elections in 2017, Map Kibera with the help of three students from the University of Nairobi and Jomo Kenyatta University of Agriculture and Technology (JKUAT), who were on an internship through the YouthMappers program, conducted a mapping exercise with the help of local community ambassadors. The main aim of this exercise was to update the security map created during the 2013 national elections.

This mapping exercise relied on information provided by peacekeeping missions (both government and non-governmental agencies) to identify the hotspots (insecure areas), i.e., places in the community known for criminal activity and had a high propensity for violence in case of social turmoil. Additionally, some areas were identified as safe places (safe havens) where community residents could run to seek humanitarian assistance in case of social unrest where they would be provided with basic needs, shelter, and medical assistance.

Before the field mapping exercise, survey questionnaires were developed and training sessions were held on the data collection process, which involved filling these questionnaires and the collection of GPS coordinates using GPS-enabled devices. A team of thirteen mappers representing all thirteen villages in Kibera was then dispatched to map the safe and unsafe places, which were characterized as follows:

Hotspots (unsafe places): These included areas that had non-functional streetlights and places that are prone to experience violence when social distress erupts.

Safe places: These included areas that had functional streetlights and areas that were close to police posts and showgrounds.

Gender-based violence (GBV) centers: These were also mapped where women and girls could seek medical and psychotherapy assistance in the case of abuse due to social unrest.

The mappers were equipped with handheld GPS gadgets and questionnaires where they would fill in the coordinates of each facility and additional information describing the condition of that facility, e.g., for streetlights, they would map if they were functional or non-functional. Additional features that were mapped included health centers and other community institutions. The entire mapping exercise took approximately one month and ran between June and July of the same year (Fig. 2.13).

Fig. 2.13 Volunteer mappers use handheld GPS and paper questionnaires for detailed data collection in Kibera, Nairobi, Kenya

5.4 Results

Afterward, the data was edited using the JOSM and later uploaded to OSM. Print maps were then designed, developed, and distributed to partner organizations under the peacekeeping missions and the police and administrative officials (Figs. 2.14 and 2.15).

The security map was also painted on the wall at a strategic point in Kibera where the community members and visitors would interact with it. The purpose of the mural was to enhance public awareness and provide community members with an offline platform for the public (Fig. 2.16).

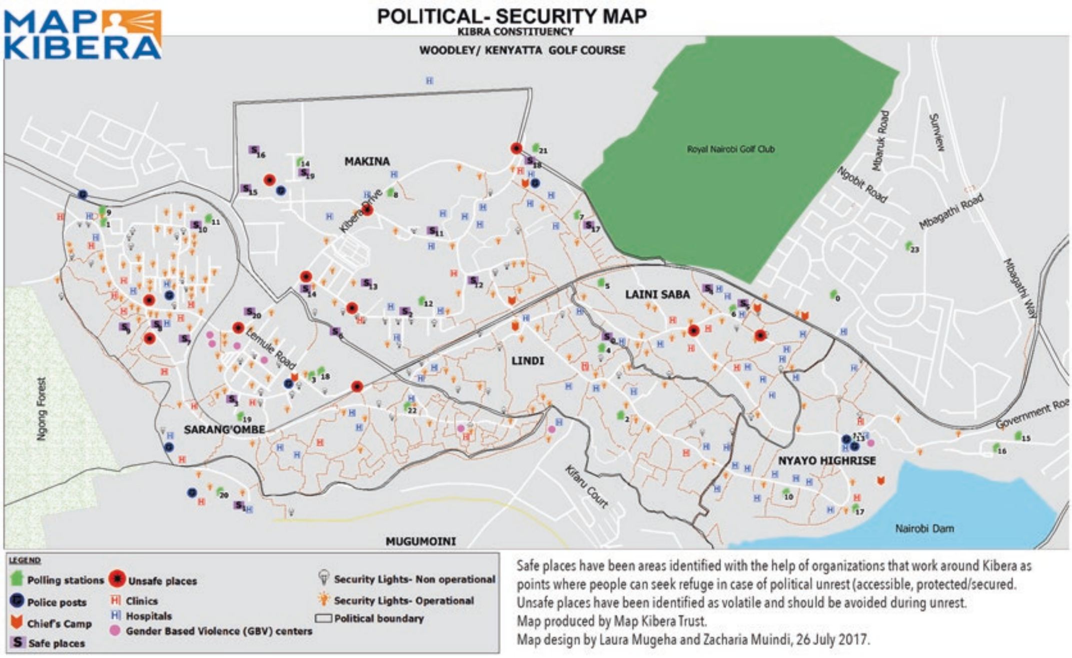

Fig. 2.14 One of the final maps of points-of-interest are distributed to partner organizations

Fig. 2.15 Administrative officials are presented the print maps developed by the project

Fig. 2.16 A mural showcases the security map via painting in Kibera

6 Conclusions

The presented case studies highlight the importance of initiatives related to the use of open-source data collection technologies and open data in informal settlements studies in different geographic contexts. Collaborative and open mapping of buildings, facilities, and services put people and communities on the map, making them visible while addressing quantitatively the need for strategies for an equal and sustainable development, especially considering the increasing number of slums around the world. Indeed, each project made evident the importance of a settlement being represented on a map as a human right, because "being on the map means being part of the city, therefore being recognized as city dweller, and then claiming certain rights as citizens" (Choplin and Lozivit 2019).

The projects carried out by the YouthMappers chapters in Rwanda, Colombia, and Kenya led to interesting insights about the adaptability of tools from the open data movement in different fields and contexts and the involvement of a wide range of expertise and backgrounds. Community projects and collaborative geospatial technologies answer the need for data and information while engaging students, researchers, and citizens in the technical process, defining a learning journey that enriches both people and locations. Map features are not created by corporations or authoritative agencies; in this way, data is gathered and owned by people themselves, redistributing power and fostering the awareness of every individual's impact in a collective environment. The results of the projects support decision-making and enable the upgrading of slums, making these areas safer and more resilient. Open culture needs to be promoted implementing strategies for communicating the obtained results, while sharing public data with local people, in order to support a larger set of data users and producers enabling the realization of a more efficient data gathering workflow.

Acknowledgments We would like to acknowledge the work done by Silvia Raviscioni and Maria Alejandra Rojas Bolaños, authors of the master's thesis "Slums upgrading: An integrated design approach for the environmental performance and social inclusion based on IMM methodology in the border between Bogotà and Soacha (Colombia)" whose data gathering phase was developed in collaboration with PoliMappers. Furthermore, we extend a special thank you to the TECHO Colombia's volunteers, who collected photos on the field with Mapillary application in the case study area. PoliMappers also would like to thank Professors Maria Antonia Brovelli and

Ludovico Giorgio Aldo Biagi, respectively, coordinator and responsible of the PoliMappers Passion in Action course, during which the mapathon for Bogotá took place virtually.

References

Abbott J (2003) The use of GIS in informal settlement upgrading: its role and impact on the community and on local government. Habitat Int 27(4):575–593. https://doi.org/10.1016/S0197-3975(03)00006-7

Chakraborty A, Wilson B, Sarraf S, Jana A (2015) Open data for informal settlements: toward a user's guide for urban managers and planners. J Urban Manag 4(2):74–91

Choplin A, Lozivit M (2019) Mapping a slum: learning from participatory mapping and digital innovation in Cotonou (Benin). Cybergeo. https://doi.org/10.4000/cybergeo.32949

Gaspari F (2020) PoliMappers at the Architecture for Smart City Course. Available via YouthMappers Blog, October 22. https://www.youthmappers.org/post/polimappers-at-the-architecture-for-smart-city-course. Cited 31 Jan 2022

Hitayezu P et al (2018) The dynamics of unplanned settlements in the City of Kigali. Laterite and International Growth Center, Kigali. http://www.theigc.org/wp-content/uploads/2019/02/Hitayezu-et-al-2018-final-report-v2.pdf

Maksimov V, Wang SL, Luo Y (2017) Reducing poverty in the least developed countries: the role of small and medium enterprises. J World Bus 52(2):244–257

ODW (2017) High level meeting: data for development in Africa. Available via Open Data Watch, June 29. https://opendatawatch.com/past-events/high-level-meeting-data-for-development-in-africa/. Nairobi, Kenya. Cited 31 Jan 2022

Rosa W (2017) Goal 11. Make cities and human settlements inclusive, safe, resilient, and sustainable. A new era in global health: nursing and the United Nations 2030 Agenda for Sustainable Development, p 339

Tadi M, Zadeh MH, Biraghi CA (2020) The integrated modification methodology. In: Masera G, Tadi M (eds) Environmental performance and social inclusion in informal settlements. Springer, Cham, pp 15–37. https://doi.org/10.1007/978-3-030-44352-8_2

UN HABITAT (2020) World cities report 2020. ISBN 978-92-1-132872-1. https://unhabitat.org/sites/default/files/2020/11/world_cities_report_2020_abridged_version.pdf

United Nations, Department of Economic and Social Affairs (2019) World population prospects 2019. https://population.un.org/wpp/Publications/Files/WPP2019_Highlights.pdf

United Nations Development Program (UNDP) (2020) Human Development Report 2020: the next frontier. Human development and the Anthropocene. ISBN: 978-92-1-126442-5. http://hdr.undp.org/sites/default/files/hdr2020.pdf