COLLABORATIVE MAPPING STRATEGY IN SUPPORT OF SLUM UPGRADING: THE CASE OF BOGOTÁ

S. Raviscioni [1*], M. A. Rojas B. [2*], F. Gaspari [3], C. Ponti [4], C. A. Biraghi [5], M. Tadi [5],

[1] Department of Civil and Environmental Engineering, Politecnico di Milano – Lecco Campus, Via Gaetano previati 1/c, 23900 Lecco, Italy - (silvia.raviscioni)@polimi.it
[2] Politecnico di Milano, Master of Science programme in Building Engineering – Architecture (mariaalejandra.rojas)@mail.polimi.it
[3] Department of Civil and Environmental Engineering, Politecnico di Milano – Piazza Leonardo Da Vinci, 20133 Milano, Italy (federica.gaspari, chiara.ponti)@mail.polimi.it
[4] Politecnico di Milano, Master of Science programme in Environmental and Land Planning (chiara.ponti)@mail.polimi.it
[5] Department of Architecture, Built Environment and Construction Engineering, Politecnico di Milano – Bonardi Campus, Via Giuseppe Ponzio 31, 20133 Milano, Italy - (carloandrea.biraghi, massimo.tadi)@polimi.it

Commission IV, WG IV/4

KEYWORDS: Open Data; Activities; Mapathon; Slum Upgrading; Mapillary; OSM; Informal settlement; IMM

ABSTRACT:
The article presents the development of a methodology for collaborating data gathering carried out remotely in a South American informal settlement for the purpose of a slum upgrading project. It was built in progress considering issues, limitations, and opportunities that arose during data collection. This text describes the creation process of the methodology as well as considerations and advice in retrospect, for those who may be interested in replicating or adapting it to similar contexts and needs.
The methodology consists of the collaboration of various subjects, on the field and remotely to facilitate, speed up and expand the mapping possibilities of informal and/or hardly accessible context, taking into account that it has been applied in a period of severe limitations due to the pandemic. The entire workflow was developed having in mind a collaborative and open framework, involving communities at different scales and adopting Free and Open Source Softwares.
In the study case, 702 Points of interest in a Bogota's slum were mapped thanks to one field survey, carried out by a local NGO using Mapillary for street-level images collection, and a collaborative mapping that involved volunteers from various nations in the OpenStreetMap environment.
It proved to have a further result in the widening of the knowledge of the involved participants and the creation of networks that could lead to new collaborations or facilitate future projects.

1. INTRODUCTION

In a predominantly urban world where urban areas have levels of inequality higher than their respective countries (UN-Habitat, 2020), it is fundamental to highlight the problems characterizing slums and to find viable solutions. Urban population growth in Africa and South America primarily occurs in informal contexts (UN-Habitat, 2016), and improving the living conditions of slums inhabitants is a crucial challenge addressed by SDG Number 11 (Sustainable Cities and Communities). In this context, the lack of adequate information due to the localization in legally contested spaces is one of the main obstacles. Detailed and standardized datasets are traditionally produced by public agencies, which often control type, storage, and dissemination, making access difficult for non-governmental agencies and researchers, especially in developing countries. Spatial data about infrastructure or socio-economic conditions are often missing in municipal databases and maps are not well equipped to support spatial responses to emergencies. Moreover, urban management agencies have the possibility of using the lack of data to justify their exclusion from formal planning and management (Chakraborty et al., 2015). The open data movement plays a fundamental role in the attempt of integrating the missing data by offering alternative sources for information. Interactive and collaborative mapping changed the production of maps from a top-down approach, with the mapping power concentrated in the sole hands of the rulers, to a bottom-up setting (Chopling et al., 2019). The ease of access by everyone allows for regular intervention, with duties carefully subdivided according to expertise, it reduces the data collection cost and the time needed for updating (Beaud, 2020).
This study presents an open collaborative strategy for the collection and publication of geospatial information, activated to overcome the lack of data necessary for developing slums upgrading projects in Bogotá. It has been implemented during the thesis "Urban Food Factory" in the Master of Science program in Architecture and building engineering of Politecnico di Milano following the Integrated Modification Methodology (Tadi et al., 2020), a multiscale and multidisciplinary approach that defines the intervention strategy for reaching the greatest chain reaction on the entire system analysed. The initial urban diagnostic phase requires the collection of a conspicuous set of geospatial information to properly model the actual system behaviour.
To decide which area would be the subject of the data collection and the redevelopment project, due to its most problematic and complex nature, it has been studied the physical and social conformation of the city of Bogotá. The city is situated on a portion of the plateau of Cundinamarca and Boyacá, bounded laterally by the river Bogota to the west and eastern Cordillera to the east. In the last few decades, the capital had undergone an accelerated growth strongly influenced by high rates of immigration from different regions of the country and from abroad. Many informal settlements take birth as the

*Corresponding to author

initial stages of the non-planned processes of urbanization in the peripheral and marginal areas, while few other slums developed in the central area as a result of the processes of the city's transformation (Rueda-García, 2003).

With the not achieved goal of creating a progressive "system of solidarity" in order to deal with the city's inequality, the neighborhoods of the capital are classified into six stratum. The stratum assigned to a block depends on the physical characteristics of dwellings, their materials, and the conditions of existence of the environments in which those dwellings are settled (Guevara, 2019). The richest stratums are concentrated in the north-eastern part of the city, while most of the workplaces are concentrated in a sizeable east-central core along major road corridors (Guzman et al. 2020). On the basis of those considerations, it was chosen to investigate a slum located in the south-eastern part of Bogota, due to the greater disadvantages and lack of amenities. In the mentioned area is situated Ciudad Bolivar, one of the world's largest mega-slums (Davis, 2006). Looking carefully at the territory boundaries is notable a conurbation phenomenon caused by the expansion of the capital slums outside the borders and its conjunction with the neighboring municipality's informal settlement. In this particular area, the lack of services is even more severe because, in addition to the difficulties of coordinating the scarce infrastructures belonging to the two cities, neither of the two feels the responsibility of providing better living conditions (Dulce Romero, 2014).

As mentioned, the project was carried out applying the IMM, which is a Holistic, Multi-Layer, Multi-scale and multidisciplinary tool, chosen as it allowed to have an objective evaluation of the morphological organization, the related environmental performances, and the qualities of an urban subsystem such as energy, green infrastructures, waste, wastewater, mobility, and food. It is structured in 4 main phases: Investigation, Formulation, Modification, and Retrofitting. The initial Investigation Phase requires a complete and updated bank of information to build a qualitative and quantitative representation of the actual urban state and performance. The aim is to dismantle the system into its main parts identified as Build, Volumes, Links, Voids, and Types of uses, in order to study the subsystem's properties and the relations between them (Masera and Tadi, 2020).

As conceivable, the data of the area is outdated and incomplete. No census has ever been carried out in the last years, and the Google Street Views, often useful to perceive and understand the context, had scarce coverage in the study area. Regarding buildings and streets information, the official GIS files of the IGAC (Colombian Geographic Institute) and OSM maps reflected an outdated reality. The inaccuracy of the data was demonstrated by a comparison with satellite images from January 2021 and pictures obtained from local contacts and it was revealed higher on Altos de Cazucà's side than on Bogota's. The information about public transport was fragmented and incomplete. On Bogota's side it was possible to identify the stops and routes of the formal public transport thanks to the online information of the SITP operator of public transport, while on Soacha's side, it has not been possible to gather this data from online sources since the buses in this area are from private entities. The local contact could provide the missing information and report lines and eventual regular stops of informal and community-based means of transport in both the parts of the study area (Raviscioni and Rojas, 2021).

The data regarding types of uses, which were the most incomplete of all, were obtained by processing existing OpenStreetMap (OSM) data integrated with street-level imagery collected on the field through collaboration with TECHO, an NGO active in the area. Specifically, the OSM information of the area, which consisted in building footprints, road networks, and natural elements - downloaded and implemented for the purpose of the study - has been enhanced with data regarding shops, healthcare places, and amenities represented as Points of Interests (POIs). The design and coordination of the activities were executed with PoliMappers, a volunteer students' group from Politecnico di Milano part of the international YouthMappers network. Then, POIs visible in the images were digitized in OSM during an online mapping session organized in the context of PoliMappers' Collaborative and Humanitarian Mapping extra-curricular course (Gaspari et al., 2021).

2. METHODOLOGY

The workflow for the collaborative activities was structured as follows: Partner engagement, co-design of the mapping activity, training on collaborative mapping methods, on-field survey, Mapathon, and data validation and sharing (Figure 1).

Figure 1. Collaborating Mapping Strategy

2.1 Partner engagement

Since the preliminary studies, it was evident that Bogotà's information is far more detailed than Soacha's one, indeed often statistics ate not related to neighborhoods or part of the city but are related to the stratum. It is not always clear if informal neighborhoods' information is included within the statistical data of stratum 6. To get a clearer picture of the area, NGO associations whose operators are locals or live in surrounding areas were involved. These associations were contacted initially by mail and then it was established a more informal communication, often via chat or video call, some will not be mentioned for security reasons. Depending on the technological means they had at their disposal and their willingness to answer our questions they gave us different types of information and materials. As for the georeferenced data, the NGO with the organizational structure and the skills but above all interest in collaborating proved to be the NGO TECHO, which started collaborating in September 2020. Their volunteers were in charge of making the on-site survey to collect the pictures needed and also defining the perimeter of the study area of Comuna 6 to collect and then map the information. Additionally, the group promoted the final mapathon through their communication channel, involving in the activity local people and volunteers.

The NGO TECHO has been contacted due to its activity in the study area and its research interest in informal settlements. TECHO is a Latin American non-profit organization that has 19 years of experience working in informal and vulnerable settlements in Colombia, seeking to overcome the situation of poverty through different actions developed by the teamwork of local communities and TECHO's volunteers. TECHO is an entity that not only works on humanitarian projects but also on different types of research and analysis of these settlements and their communities to understand the most suitable actions to execute and the intervention areas to develop. Their investigations – shared through papers, online maps, and other publications - included analysis of slum location, accessibility to basic services, socio-demographic data, natural and natural threats, needs, and socio-economic problems. describing the data gathering process carried through fieldwork, local interviews, and online tools.

Coincidentally, TECHO was planning to developing a research project in another informal settlement, Comuna 6 of Soacha, called San Humberto, which was near the project study area. According to the director of the NGO in Bogota, the settlement of their interest was going through the same informal pattern of urban illegal expansion similar to the one that occurred in Altos de Cazuca a few decades before. Therefore, a common interest has arisen to combine skills and knowledge to advance in both projects simultaneously, reducing the timing and enriching both partners. In fact, some operators of TECHO Bogota had already experimented with platforms for data collection thanks to the use of street-level imaginary taken by smartphones and were particularly interested in expanding knowledge in this regard.

Since the thesis group was composed of building-architectural engineering students with limited knowledge of the management of open data tools, it turned out to be necessary to contact an association with experience in order to guide the organization of data collection. In October 2020 it has been involved PoliMappers, an educational community based at Politecnico di Milano and part of the global network of YouthMappers. The group, active since 2016, is composed by volunteer students that have the mission to train and motivate the next generation of volunteer mappers and to do mapping using free and open-source software and OpenStreetMap through a dedicated meeting called "mapathon". The main goal of this partnership was to promote mapping using open-source technology and to ensure open up-to-date data, which coincides with actual reality and which quality has been validated by expert mappers, although it has been also an opportunity to encourage new people in learning more about the subject and to apply these tools in other informal contexts.The discussion and organization of the collaborative mapping were developed through different online meetings. PoliMappers' volunteers delivered training to the partners involved, had a fundamental role in the organization of the mapathon event, and chosen the most appropriate tools and platforms where to host and promote the collaborative project. Indeed, The mapathon was included in a course at Politecnico di Milano named "Collaborative and Humanitarian Mapping" within the innovative teaching offer proposed by the university. This extra-curricular educational activity that the university offers to its students to encourage the development of transversal, soft and social skill, coordinated by Professor Maria Antonia Brovelli.

In addition, it is important to mention that during the development process other stakeholders were involved. Through the international organization of YouthMappers it was

Tab 1. Tasks and common benefits of the partners.

Partner/ Stakeholder	Tasks in the collaborative mapping	Benefits and learnings from the experience
TECHO NGO	• Collection of street-view images through Mapillary • Promotion and involvement of local participants in the Mapathon • Definition of street to survey in San Humberto	• Learn new digital tools for data collection through the use of available devices such as smartphones • Learn about new open data platforms to record and share the information in an immediate way • Meet new organizations for future collaborations in data collection • Exchange of information on the areas where the NGO is active • Learn new methodologies for the study of informal settlements • Fieldwork information of San Humberto area already mapped on the OSM platform thanks to the mapathon event
PoliMappers	• Online trainings for open data tools • Organization of mapathon event • Promotion and involvement of people for mapathon	• Promote mapping using open-source technology and to produce open data • Opportunity to encourage new persons to know about open data tools and to map, such as TECHO's volunteers and the thesis team, • Propose a new mapathon where new open data were produced. • Opportunity to work in a different an urban context, in informal settlements where this kind of information usually is almost absent.
Thesis team	• Involvement of partners. • Definition of areas of intervention. • Mappers of the information collected.	• Learnings about open data tools to face the common problem of lack of up-to-date information in the slums. Applicable in future projects. • Obtaining pictures of the NGO's field work, useful for a better understanding of the study area • Obtaining information on the types of uses in the area • Obtaining updated information about informal and formal actives.

possible to have support for promoting the mapathon event on different platforms, engaging people at both international and local levels. Indeed, the involvement of the Semillero GeoLab UdeA, a Colombian chapter of YouthMappers, made it possible to contact local students interested in mapping and open-sources technology with knowledge of the geographical contexts and peculiarities. To engage the different stakeholders in the collaborative mapping, it was important to first understand the possible synergies, the general and individual benefits and learnings for each partner, and also their role in the process. The tasks and common benefits are summarized in table 1.

2.2 Co-designing of the mapping activity

Once the protagonists and roles had been defined, the next phase of activities planning began. It was carried out through a series of meetings between the partners involved made over a period of one month., taking into account some indications given by a small NGO arisen on the territory by the will of the inhabitants.

To understand the organizational difficulties of this activity it is necessary to have a general picture of the morphology of the studied area and of the society that occupies it. The entire informal settlement has been developing since 1975 in natural areas characterized by steep slopes and landslide hazards. Soacha, being one of the main receiving municipalities of displaced people in Colombia (ONU, 2006), is a place of poor governance and limited municipal investment capacity, describable as a "dormitory city" relying on Bogotá's employment capacity. As a result, Bogotá–Soacha has the most intense flow of people and services in the region. On the other hand, road infrastructure in the municipality is precarious at best, with only four access points to the main artery connecting to Bogotá, resulting in high congestion and long walking times (Hernandez & Dávila, 2016).

The situation is even more severe in informal settlements, where the few roads accessible by vehicles are narrow and irregular, and whose lack of pedestrian corridors and sidewalks limit both motorised and non-motorised mobility. In addition to the inadequacy of the street network, the internal connections between districts are made further difficult by the rivalry between the inhabitants of different sectors (Gutierrez & Gibbons, 2020).

Based on the collected information about the context, a decision on which tools to use and which roads to survey was made. As for the tool was chosen to use Mapillary, for its possibility to capture geolocated street-level imagery with different modalities: through a synchronization of a GPS-tracker and a camera device or with a simple application downloaded on an easy-to-use smartphone mounted on a car or a bike. Considering the flexibility and the reduced cost of the use of commonly used mobile devices, the second modality was adopted. The key element that led to the adoption of this tool, however, was its integration with the OSM environment that, as previously tested by the PoliMappers group, makes possible to interactively visualize Mapillary photo-sequences inside OSM-editors (iD and JOSM), enabling the possibility to edit or add new element to the map by comparing the geolocated images with the available satellite imagery.

As for the roads to be covered, the decisional process was more complex. Given the time span of a master thesis and the large extension of the study area, it was clearly impossible to carry out this procedure on the whole informal settlement. It has therefore proved necessary to select the roads in such a way that the quality of the information would not be excessively affected.

As the COVID-19 restrictions had made unviable an on-field inspection, an initial visual inspection of the area was conducted remotely with the support of the few outdated images present in the GoogleStreetView database to have a greater understanding of the place conditions as well as the actual data coverage of the area.

Subsequently, the previously mentioned local NGO has been contacted and their representative explained that the network relies on a few old streets with the highest concentration of commercial activities and services, whose branches are almost exclusively residential. The main roads were easy to identify as they are characterized by the presence of brick buildings with a greater number of floors while, moving away from these, the number of floors decreases as well as the quality and robustness of the buildings, whose in the peripheral areas are barracks made of wood and metal plates. Such urban structure has been confirmed by NGO Techo and by the careful observation of constructions materials and shadows visible in satellite images and later validated by the photos captured with Mapillary.

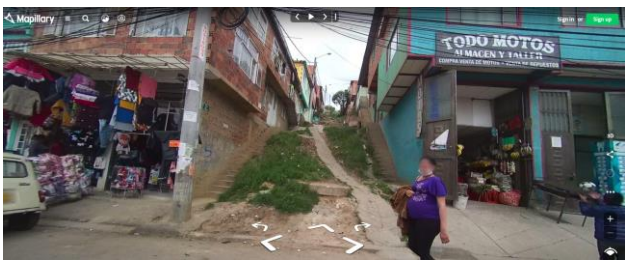

Figure 2. Mapillary image

2.3 Training

The training was organized by PoliMappers, whose representatives, based on past on-field activities of the group, dealt with the design and presentation of information material about the application, its correct use, and the problems or doubts that could have been encountered at the time of data collection. Two meetings were organized: the first one was dedicated to the introduction of the OSM environment and the Mapillary platform while the second one was more focused on practical tips and suggestions for the field survey, with a special attention for Mapillary collecting modalities (manual or automatic) for reducing inconsistencies or geolocation error in the data collection. For these reasons, the second session became on occasion to share with the participants group possible acquisition settings (positions of devices on car and their caputaring mode) depending on the field scenario. In addition to the thesis group and the representatives of PoliMappers, Eight TECHO's volunteers participated in the online event, more people than those needed for the collaboration were interested in the topic. All the produced training materials was delivered to the participants, allowing them to learn more with additional references and to integrate it with personal experience for future work with their local communities.

The video call has indeed proved to be a useful exchange of knowledge for all actors in the field. In addition to context information that allowed to calibrate at best the analyses to be carried out and the data to be collected, TECHO volunteers shared their data gathering experiences with different applications in the past, formulating together possible future integration of those with Mapillary and OpenStreetMap.

2.4 On field survey

The actual fieldwork was planned between December and January, but the pandemic restrictions imposed by the local authorities did not allow free movement. For this reason, the survey was delayed by a few months and could finally take place in February 2021. In the waiting time, TECHO shared the final version of the driving plan with the streets to be surveyed for their study in Sant Humberto, integrating it with the information on the road network for the thesis purposed identified through a QGIS project based on the data collected in the co-design phase.

For volunteers' safety and for its rapid application, it was decided to cross the area by car, and capture the images with 3 mobile phones fixed inside the car with a simple tape of scotch tape to the two rear windows and the windshield. These, directed in three different directions, had the ability to give a detailed view of the road thanks to a continuous set of photos collected adopting the automatic modality of Mapillary with a 5-meters interval based on the devices' GPS signal. In fact, it has been selected the automatic setting referred to space and not to time, due to the unpredictability of the car's trajectory due to the road condition.

The street-level imagery capture did not take place comprehensively, as one side-mounted phone did not work properly for the whole duration of the survey. Nevertheless, this loss of information was not considered to be relevant for the overall outcome as the problem occurred in the most peripherical sector of some selected streets and in the connection in between them. Hence, the geolocated images were analyzed by the project team, removing duplicates, blurry photos, and pictures with incoherent geolocation along each sequence. After this preprocessing, the collected sequences were uploaded to the Mapillary database through the mobile application.

Figure 3. Streets of Survey, Techo

Figure 4. Pictures of the fieldwork by TECHO

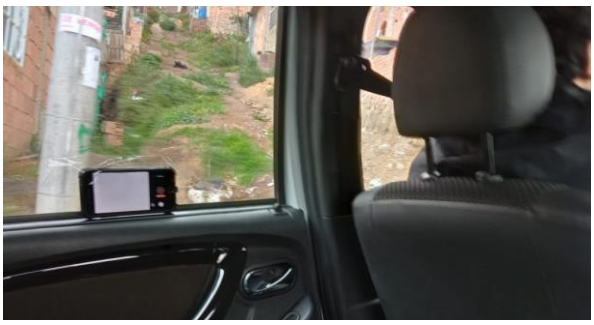

Figure 5. Pictures of the fieldwork by TECHO

2.5 Mapathon

Following the field survey, an unforeseen organizational issue in the uploading of images occurred due to a Mapillary server problem. The data was not uploaded for days in the application database and was not visible even then on the JOSM, the OSM editor that was initially chosen for the mapping process thanks to its time-saving Mapillary pug-in and advance digitizing options. Therefore, it was necessary to change the editor to the iD editor integrated into the OpenStreetMap website as it was the only one visualizing the collected data. Consequently, the previously defined collecting areas was compared with the actual final Mapillary coverage, re-defining the area to be mapped based on the previous observations. Hence, the boundary of the zone was used for the creation of a dedicated mapping task on the TeachOSM Tasking Manager (Project #1270, https://tasks.teachosm.org/projects/1270), preparing a collaborative project for the next mapathon and avoiding conflicts between the activities of different contributors. Additionally, detailed information on how to contribute were included in the project description, embedding all the references to useful documentation prepared for the mapathon event. In this way, even people that did not have the opportunity to attend the event could have the possibility to understand the aim and the context of the project, contributing to it with explained guidelines on satellite imagery to be used as reference, tagging scheme and Mapillary visualization and interpretation in iD.

To ensure the success of the mapping event, given the organizational difficulties caused by the pandemic situation, it was necessary to put a considerable effort in the promotion of the online event. The institutional and social channels of all the partners engaged in the project have been exploited, in particular the pages of Instagram, Facebook, LinkedIn, Twitter.

The mapathon, included in the PoliMappers innovative teaching program "Collaborative and Humanitarian Mapping", took place virtually on the Zoom platform and broadcasted live on the PoliMappers Twitch channel. The entire streaming was supported by YouthMappers, IMMdesignlab, TECHO Colombia and the Colombian YouthMappers chapter based in Medellín, Semillero Geolab UdeA (Gaspari et al., 2021).

The participants were more than 80 from different backgrounds and from all over the world, but only a part of them gave a significant contribution.

The meeting consisted of three parts:

- A presentation 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
- A tagging and mapping tutorial carried out by PoliMappers officers that gave suggestions and highlighted possible issues

- A guided mapping session during which attendants followed the required steps to display and explore Mapillary image sequences on iD editor, evaluating the position of points of interest by using both street-level and satellite imagery, and create or edit the targeted features on OpenStreetMap

Due to the internationality of the 39 participants, who were mostly unfamiliar with the context and the Spanish language, it has been provided an instructions file with detailed guidelines regarding the tagging choice of shops, amenities, craft places, and healthcare points, drafted with the help of TECHO volunteers that have familiarities with the area. Some local contributors to the mapping event were continuously helping foreign contributors to understand the context of the mapping area, explaining the kind of visible amenities, indicating how to spot them, and helping to interpret shops' signs.

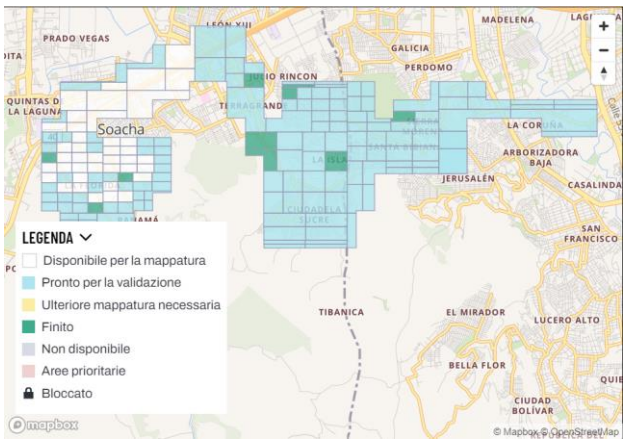

Figure 6. Screenshot of the online task on TeachOSM Tasking Manager during the Mapathon event.

2.6 Data validation and sharing

Considering the diverse background of the mapathon's attendants, a validation of the contribution has been defined by PoliMappers team members. In this students-led phase, the map changes tracked in the TeachOSM task were analysed identifying possible mistakes or inconsistencies. Hence, the OSMCha tool was adopted for understanding which and how nodes and ways were affected by users contributions. PoliMappers validators, in case of errors, fixed mistakes on OpenStreetMap by comparing the added or edited elements with the street-level or satellite imagery, ensuring the good quality of open data. A significant effort consisted in checking the tags assigned to map elements by assessing their congruences with the destination of use of the points of interest depicted in the collected images. Also, comments on OSM changeset were made providing constructive suggestions to the contributors for making them more familiar with both the mapping and the tagging scheme of OpenStreetMap. Most of the errors, indeed, were related to wrong tags semantics that could be due to the little experience of the majority of the contributors - 90% beginners, 7% intermediate and 3% experienced mappers contributed to the task as documented by TeachOSM. At the end of this phase, 508 shops, 177 amenities, and 17 healthcare places were validated and visible on OpenStreetMap as the result of the mapathon contribution.

A deeper analysis of the type of uses information and its correlation with the road network, build volumes, and voids are provided by the freely accessible thesis work, which contain also data related to the management of water, energy, waste, food, green infrastructures, and transport that could be considered for further considerations.

The results achieved were advertised in all the previously mentioned means of communication in addition to the Politecnico di Milano's website news section.

Due to the interest generated in the Latin America mapping community, the thesis writers were hosted in a webinar organized by Semillero Geolab UdeA with the purpose of sharing the detail of the mapping experience and some indications and suggestions for who is interested in repeating the methodology. The event was streamed on the 26th of August for YouthMappers members of all South America.

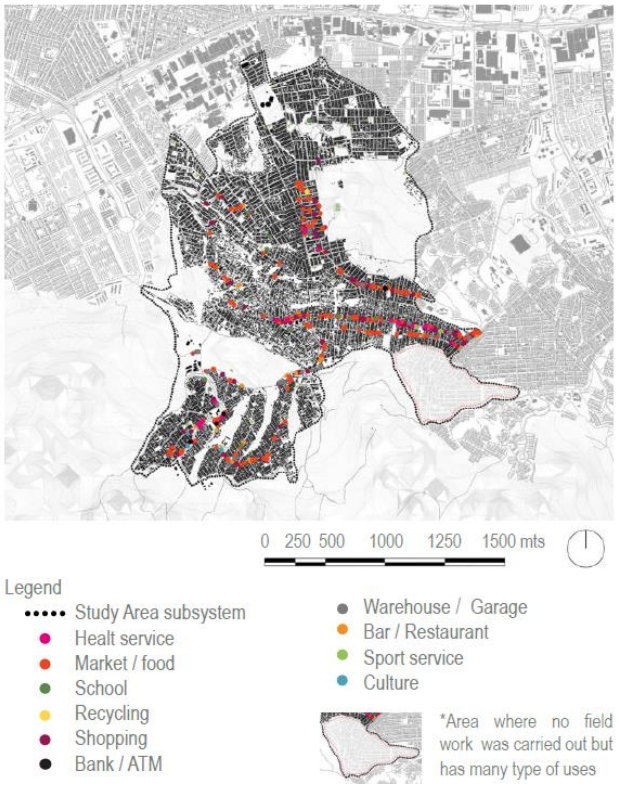

Figure 7 . Map of type of uses.

Figure8. Flyer of event organized by Semillero Geolab UdeA

3. CONCLUSIONS

The results of this mapping experience were multiple. First, the creation and testing of a strategy that could be replicated for mapping informal contexts in support of slums upgrading projects. Nevertheless, the field of application is not limited to informal settlement, as the methodology can be applied or taken as a reference in projects whose field works are not feasible by the research team due to mobility restrictions, that in this case were caused by the pandemic context, but could happen for various different motivations.

The initial investigation process that led the team to the development of this strategy revealed the scarcity of study cases about the application of open data tools in informal settlements to solve the problem of outdated official maps. This prompted the project team to share through different social media the experiences of this strategy process, with the aim to reach and connect people and associations sharing the same difficulties using a second channel more immediate and easier to consult than the academic one. Thanks to this practice, the group had been contacted by entities such as the Colombian NGO iMMAP with which occurred an interesting exchange of experience and knowledge.

Secondly, the creation of information about the activities (508 shops, 177 amenities e 17 healthcare places) and 1571 street-level images on 32 kilometres of an urban context until then not covered by open or private platforms. Although, when the collaborating mapping involves people living in different countries, it is fundamental to consider the limited context understanding of participants. To face this limitation, it is necessary to do a preliminary study of the context and of a sample of the imaginary collected to structure an effective guide for the non-local mappers. In the study case, it was shared a detailed tagging guideline made by PoliMappers together with links to recommended translators defined together with TECHO members and native speakers. The adoption of Mapillary and OpenStreetMap as tools for open mapping is however affected by significant limitations linked to the type of mobile device used for the survey, concerning the quality of images and the low accuracy of GPS signal. Dealing with Volunteered Geogrpahic Information (Goodchild, 2007), internet accessibility and capacity of available technological equipment should be carefully considered when defining the goals of the project and its accuracy requirements. Already mapped highways present in OSM and up-to-date aerial imagery could then represent useful information whose availability has to be considered during the design phase.

The last achievement of the given case study consisted in providing an example of an international project that involved local communities and students during a global COVID-19 emergency, fostering innovative learning experiences as well as social engagement through the sharing of open and collaborative knowledge and technologies. The most beneficial exchange for our aim was training local stakeholders with key competencies for carrying on their precious on-site activities. Although, this experiment actually enriched even the most experienced of the team as it gave additional skill in solving some of the possible technical and not technical issues that could be faced in a remote and collaborative mapping, highlighting the role of the community behind collaborative projects.

For the success of the methodology replication, it is recommended to involve the characters indicated in Tab. 2.

Table 2. Success of methodology replication

Stakeholder	How to find	Duty
Research team	-	Select the necessary dataset, evaluate the compromise between time, quantity an precision of data. Advertising the mapping event and sharing project phases.
Local association / International association with a local base	Association operating in the same field as close as possible to the selected territory, that could share common interests.	On-field survey, suggestions, and explanation about the morphology and society of the studied area.
Neighborhood association or community contacts	Local established associations, possibly risen by the population's need and will.	Confirm information found on internet or provided by other administrative sources. Provide additional information
Association with Mapping competence	International network of Mapping, YouthMappers network. (If the research teams does not have those skills)	Identify the right platforms to use, train the other stakeholders, organize the technical part of a Mapping event and solve eventual issues.
Volunteer mappers	International mapping network, University	Participate in the mapping event making it possible to reduce the mapping time or expand the covered area increasing the completeness of the dataset compared with the expect result of the research team alone.
Local volunteer mappers	Advertising in loco, just if this can be made in a safer manner	Giving punctual explication of the context during the map event. There would not be a necessity in case of participation of some representative of neighborhod association.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the crucial contribution of Prof. Maria Brovelli and Ludovico Biagi in their role as coordinators of the course "Collaborative and Humanitarian Mapping".
An important contribution came also from Semillero Geolab UdeA, the Colombian chapter of Youthmappers, that supported the promotion of the activities through their network and took actively part in the mapathon.
Finally, the authors would also like to thanks Daniel Martinez (Director of TECHO Bogota) and his team for their support and interest.

REFERENCES

Beaud, R. (2020). Open Geodata - A support to humanitarian aid: An analysis of 'OpenStreetMap's Crowdsourcing and open data benefits, (University of Bern)

Chakraborty, A., Wilson, B., Sarraf, S., Jana, A., (2015). *Open data for informal settlements: Toward a user's guide for urban managers and planners, Journal of Urban Management*

Choplin, A., Lozivit, M., (2019). *Mapping a slum: learning from participatory map and digital innovation in Cotonou (Benin),* University of Geneve

Davis, M. (2006) Planet of Slums, La Découverte, Paris, (ISBN 978-2-7071-4915-2), p. 31.

Romero, D. 2014: Altos de Cazucá, tierra de nadie, El Espectador 31 ott 2014

Gaspari, F., Stucchi, L., Bratic, G., Jovanovic, D., Ponti, C., Biagi, L. G. A., and Brovelli, M. A.: INNOVATION IN TEACHING: THE POLIMAPPERS COLLABORATIVE AND HUMANITARIAN MAPPING COURSE AT POLITECNICO DI MILANO, Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci., XLVI-4/W2-2021, 63–69, https://doi.org/10.5194/isprs-archives-XLVI-4-W2-2021-63-2021, 2021.

Goodchild, M. F. (2007). Citizens as sensors: the world of volunteered geography. GeoJournal, 69(4), 211-221.

Guevara S. and Rob Shields, « Spatializing Stratification: Bogotá », Ardeth [Online], 4 | 2019, Online since 01 May 2020, connection on 22 December 2020. URL http://journals.openedition.org/

Guzman, Arellana, Alvarez, Confronting congestion in urban areas: Developing Sustainable Mobility Plans for public and private organizations in Bogotá, Transportation Research Part A: Policy and Practice, Volume 134, 2020, Pages 321-335, ISSN 0965-8564, https://doi.org/10.1016/j.tra.2020.02.019.

Rueda-García, 2003: Understanding slums: Case Studies for the Global Report on Human Settlements - The case of Bogotá D.C., Colombia

Raviscioni S., Rojas B. M.A., 2021 URBAN FOOD FACTORY Slum's upgrading through an integrated design approach for the environmental performance and social inclusion based on IMM methodology in the border between Bogotá and Soacha (Colombia), Politecnico di Milano.

Tadi, M., Zadeh, M. H., & Biraghi, C. A. (2020). The Integrated Modification Methodology. In *Environmental Performance and Social Inclusion in Informal Settlements A Favela Project Based on the IMM Integrated Modification Methodology* (Research f, pp. 15–37). Springer.

UN-Habitat, *Slum Almanac 2015-2016. Tracking Improvement in the Lives of Slum Dwellers* (Nairobi, UNON, 2016)

UN-Habitat (2020) United Nations Human Settlements Programme. *World Cities Report 2020,* Nairobi, ISBN: 978-92-1-132872-1