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Supervisor: Jamal Jokar Arsanjani

Written by: Monica Gandino

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### Abstract

Mapping highly populated areas like slums can represent a very challenging task, the lack of information about these areas can delay decision-making for possible solutions.

The project aims to build a VGI tool for slum data collection taking in consideration examples of community-based mapping and Participatory GIS.

The work focused in the case study of Petare located in the city of Caracas, Venezuela.

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### Abbreviation

CSS	Cascading Style Sheets
GI	Geographic Information
GIS	Geographical Information System
GPS	Geographical Position System
HTML	HyperText Markup Language
NGOs	Non Governmental Organization
ONU	Organization of United Nations
PGIS	Participatory Geographic Information System
PHP	Hypertext Preprocessor
PPGIS	Public Participatory Geographic Information System
PSUP	Participatory Slum Upgrading Programme
SWOT	Strengths - Weakness - Opportunities - Threats
UN	United Nations
URL	Uniform Resource Locator
VGI	Volunteer Geographic Information

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# 1 Introduction

The purpose of this research is to build a VGI prototype that can be used for slum data collection, to accomplish the goal it was fundamental to delve into the concepts of Volunteer Geographical Information, Participatory GIS and Community Mapping. In the following pages it will be discussed the concepts. Volunteered Geographic Information is intrinsically related to the participation of people therefore it is important to identify how the phenomenon differs or complement with the concepts of PGIS and communitary mapping. The chapter is concluded with a comparison of both Participatory GIS and Volunteer Geographic Information.

### **1.1 Volunteer Geographical Information and Participatory GIS**

The concepts of Volunteered Geographic Information and PPGIS are fairly recent, the technological advances made in the past decades have provided the society with a wide range of innovative tools that have made possible the collection, processing and analysis of geographical data. These two concepts consist in the engagement of the public citizen in the collection of georeference data (Hachmann et al, 2018).

Considerable contributions have been made in the subject, platforms such as Openstreetmap (https://www.openstreetmap.org), have made possible huge amounts of georeference data collected by volunteers and contributors. The phenomenon, as well, has shorten the relation with the public authorities at many levels, as an example the platform Fixmystreet can let you "*report, view or discuss local problems*" from a personal computer or a smartphone (https://www.fixmystreet.com/) allowing the input of citizens to report the status of streets, lighting and public furniture for municipalities to address the solutions of these issues.

These tools, nowadays, are also been applied within participatory mechanism such as PGIS and community mapping, public citizens can contribute directly to the identification of issues in a determine area of interest, it can be used to highlight problematics in the territory making it simpler to address and solve them. Johnson and Sieber (2012) argument that VGI can strengthen the citizen-to-government-to-citizen interaction by taking in consideration the citizen perspective and this leading to take better actions and policies. The implementation of VGI can give visibility to local issues, and these issues can open a discussion with different levels of government but, also it can cause, pressure from local authorities to a national level meaning that citizens could open cross-scale discussions different from the formal decision-making structures.

The contributions made by citizens have arised issues regarding the legal framework over land property rights, subjects related to land are complicated since it can have a different impact between different groups of people, Sieber argument that to reconcile these contradictions and balance opinions, it is necessary to have a wider picture of a problem and that it can only be possible when information is accessible "decision-makers must rely on data and information that can be defended as valuable input from citizens and reflective of real citizen concerns" (Johnson et al., 2013, p.76).

McCall et al. (2015) recognise the importance of local people knowledge in participatory processes within PGIS and how VGI can benefit from these practices, and in their comparative analysis it is emphasized that inhabitants of a determine community provide their own understanding and perception of the local and social environment as well as weaknesses and the potential opportunities. These capabilities are being recognised to a greater extent by policy-makers, politicians and researchers. Using McCall analogy, VGI works as the electronic sensors used to measure the quality of water, air pollution or transportation networks, only that in this case, people are collecting qualitative and quantitative information through their mobile devices, the information then will be share and it will be use, just as the electronic sensors as a way to report the conditions on different issues, this phenomenon it is also known as human sensors web.

Although the engagement of people in PPGIS and VGI practices is fundamental, these practices differ from one another as seen in fig. 1, on one side PGIS is more related to small

groups normally accompanied by actors in direct contact with their participants giving transparency to the process and, in the long run, creating an atmosphere of trust in the process. This differs from VGI practices where single participants of small groups voluntarily engaged in the task, collecting information with little or absent interaction of stakeholders, this can become a threat to the process itself and compromise the trust and the purpose of the project. It is interesting to notice that the contribution from the groups in VGI practices are larger than PGIS, were is based on small sample of people which are normally selected by some criteria, while for VGI can result in a greater sample but with an inclination towards specific socio-economic groups. The differences are as well represented by the information flow, where for PGIS tends to be lower with slow feedback rather than the high frequency and fast response of VGI.

Participatory GIS	VGI
Small groups	Aggregation of individuals OR of small groups
High degree of participation	Low OR medium degree of participation
Two-way, multi-party interactive	No OR little interaction - likely to be one-way flow. Searchable
Transparent process - actors and their inputs are known and visible	Not transparent - actors are unknown, manipulation of actors' inputs is feasible
Trust is created over time, and by peer validisation	Creating Trust requires other forms of Validation
Small sample of people, usually selected by some criteria	Large sample of people but biased towards specific socio-economic groups (there is a "long tail effect" statistical distribution)
Low frequency of information flow. Slow response times	High to very high frequency. Fast response time, if needed

Huge time investment, slow, very slow	Small time investment, fast
Normally voluntary, but	Voluntary (voluntary at initiation, but can become more opportunistic)
it can be dominated by cliques	Difficult to dominate
Empowering on a small scale – generates confidence, capacity and satisfaction	Empowering - for society on a macro (political) scale, but not usually at the individual level
Richness and depth of information / knowledge	Unlikely to be rich and deep data / information
Explanation and understanding created	Description, and more amenable to statistical analysis

Fig 1. Differences between PGIS and VGI (McCall et al., 2015)

One of the things this practices contrast enormously is the time factor, for PGIS to be effective it needs a ground preparation before it can produce any technical outcome, the information needs to be clear for the inhabitants of the community, also, the enrolment of community leaders is important to generate trust. The volunteer nature of both are also different, the assignment of project leaders in the early stage of the process leads to a more successful outcome (IIED, 2006, pg 95) whether in VGI the tendency of participation is organic and without following any hierarchy it can become opportunistic, this might have to do with the primary purposes and for whom is going to be beneficial the data collected (McCall et al., 2015). Although the final outcome of both practices in theory, is the collection of geographical data, it can be say that PGIS processes contributes only to the empowering of those who are working closely with the process, but the outcome might not have an impact on a macro level as VGI that will benefit a larger number of people.

The outcome of PGIS is more likely to be useful to create insights of a particular issue, it will provide more detail information and thus better understanding as opposite to VGI where the amount of data generated will be more beneficial for statistical analysis without any specific target.

The differences between methods and purposes are clear, both of the practices have different scales of action but one cannot exists without the other. The concept of VGI as, establish by many researchers and professionals, is the use of tools to create, assemble, disseminate geographic data collected voluntarily (McCall et al., 2015) while it have been established for some researchers that PGIS are participatory processes where citizens and grassroots organizations use geo-spatial information (GI) or GIS technology for data collection, mapping, analysis and / or decision making, normally on specific issues that have a direct impact on their lives (Tulloch et al., cited in McCall et al., 2015). Among other related concepts to VGI there is also a branch called PPGIS, which it stands for Public Participatory GIS, the outcome and the usage are quite similar to the practices describe before. Public Participatory GIS was a known practice use to emphasize the importance of citizens typically adopted by planners (Obermeyer, 1998 cited in Panek, 2011). The literature is quite extensive, the concepts update with the pass of the time and with the arrival and spread of technology, in some cases overlapping. Panek makes a curious statement on PGIS and

PPGIS, which their concepts are quite alike, he refers to PPGIS as "mainly to the activities more often practiced by *the public* in the Global North countries, while PGIS refers more often to the activities practiced in the Global South countries, sometimes by the same groups of people from the Global North" (Panek, 2011, pg 236).

Taking in consideration the concepts presented before, It can be concluded two key factors for the development and success of participatory practices involving VGI, having a purpose will help the precision of what aspects of the territory will be considered and the cognitive precision needed from the participants as well as which tools will be implemented, it will determined questions regarding for who is beneficial the project, who are going to be the volunteers (Rambaldi et al., cited in McCall et al., 2015). The secondary factor to be considered is the accuracy of the data collected.

All parts involved, need to have a clear idea of the kind of information that is expected from them and why this information is needed, therefore discussions on what is reliable information is essential, the fact that all parties involved have the sufficient knowledge of the task creates trust between volunteers. Understanding better the purpose will benefit the creation of better tools and practices.

### 1.2 Slum upgrading and Volunteer Geographical Information

The continuing and fast growing of urban areas has brought enormous challenges to all levels of governmental and international institutions, by the year of 2015 the percentage of the world population living in urban areas was 54 per cent (World Cities Report, 2016) more than half of the world population is now living in urban areas and the numbers are in continuing raising. The numbers are daunting, from 4 billions of people living in cities, one billion lives under slums conditions (PSUP, 2016) to be more specific, according to the Human Settlements Program from United Nations by the year 2016 one in eight people lived in informal settlements or so called slums.

Slums were defined by the United Nations Settlements Program (2003) as the adjacents settlements of the formal city, with inadequate housing and lack of basic services, normally

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not taken as an equal part of the city since they are not recognized of addressed by the public authorities.

In spite of the different names (barrios, favelas, slums, shanty towns) and typologies associated with this phenomenon, the characteristics are fairly the same and dwellers can suffer from one of more house deprivation. No security of land tenure, limited or no access to drinking water, insufficient living space; normally high density places with overcrowding problems, limited or no access to sanitation facilities; a well known example can be found in slums in India where the limited amount of toilets per population is not sufficient to meet the demand, contributing to the spread of diseases. In addition of all the aforementioned complications, violence and crime are also characteristics that aggravates the situation (World Cities Report, 2016).

The several agendas promoted by the United Nations Human Settlements Programme throughout the past 20 years has proven to be, in some cases, insufficient to address the problems of informal settlements, as the World Cities Report from 2016 states, the agendas were too general with the recommendations and too difficult to follow by policy makers and governmental institutions bringing as a result difficulties to manage and monitored the agenda itself (World Cities Report, 2016). One thing that can be notice from the past programs promoted by the ONU was the recognition of NGOs and civil society organizations, the second UN Conference on Human Settlements held in Istanbul in 1996 was the first time that these bottom-up organizations were taken into account and were invited to participate with recommendations and ideas, since then it has become more common the adoption of bottom-up strategies promoted by the United Nations and governments to mitigate some of the problematics within urban areas.

Some policies tried to mitigate and prevent the continuing spreading of informal settlements by adopting harsh measurement like eviction and resettlement of their inhabitants, as for today these practices have proven to be ineffective and expensive; eviction and demolition policies (World Bank, 20013) predicated in past agendas are shifting towards the promotion of policies against forced eviction and the encouragement of national and local efforts to promote multidisciplinaires solutions involving authorities, community and technicians (PSUP, 2015). The new approach on informal settlements has shift towards in-situ

improvements, consisting in physical renewals as well as social and economical stimulation. These practices have been compile with the name of slum-upgrading and they seek to integrate the informal settlements with the formal city (PSUP, 2015).

Achieving a good slum-upgrading practice will require, as for any other renewal project, information about the state of many things inside the community, it will require up-to-date data that, in some cases in developing countries is not available at government level.

In an interview made to Aromar Revi, Director of The Indian Institute for Human Settlements (PSUP, 2015) on Participatory Slum Upgrading the question on *How can* countries contribute to operationalized the Sustainable Development Goals and the New Urban Agenda's data revolution, and in which ways can localised data collection and monitoring can be institutionalised? His reply:

" [...] it requires action on the ground. The frontline of this process lies with local and regional governments. [...]the world is a very complex and diverse space, especially when we come to urban areas and the regions that surround them. Hence, what may be important in one location may actually not be critical in other. So, universal goals and indicators are important to measure at national level, but the localisation of the processes of intervention, management, monitoring and evaluation is very crucial. If we don't actually measure things that are important to communities, to local and regional governments, we will never know how much progress we are making [...]"

Information and Communication Technology has had a major impact in cities for the past years. The rapid deployment of information and technology has had an impact in the way cities have been shaped as well as the revolution of data collected from cities has improved decision-making also has brought trends like smart cities into some cities around the world (World Cities Report, 2016). The importance that data has gained in modern cities, especially in the Global North has put in the spotlight fields like GIS, which has been transformed due to the rapid deployment of open source tools and the web 2.0.

Although many experts in the field have recognised the importance of collecting slum data to come up with a better planning, many are the discussions regarding the quality of the data collected by volunteers. It seems that the debate has been focalized more in the quality of the data obtain by VGI processes in slums rather than the advantages these tools may have in this complex environments (Hachmann et al., 2016). Another issue that arise is the adoption of PGIS in slum data collection, which puts more effort into the process itself but it is not driven by citizens, in much of the cases is more likely to be driven by agencies bringing into the data collected (Hachmann et al., 2016). Erica Hagen (2011) refers to this in *Mapping Change* alleging that in Kibera, where the project Map Kibera was based, many where the NGOs and community based organizations collecting data inside the area but the data was never shared to the Kibera's residents. This lead us to think how GIS can empower people and how much can influence policy decision? and on the other hand the concerns on whether the data would be use to stimulated innovation and encouraged social change instead of be a extractive practice (IIED , 2006).

The complications around mapping informal settlements are many, which practices should be adopted? How this practices can permeate into the residents of informal settlements? It is necessary to establish a common based between the different concepts of VGI, PGIS and community mapping reflected in a real context to understand more deeply the limitations of slum data collection.

The discussions around the quality of the data obtained through VGI tools is a fair concern yet another obstacle may obscur the process of data collection in informal settlements where the nature of voluntarism is perceived differently among their inhabitants. Not only that the dwellers can be extreme caution towards outsiders (IIED, 2006) but in some cases, as Hagen (2012) affirmed, "pure volunteerism could not long be sustained in slum-based information work members eventually needed to be paid; free time was at a premium". Another issue that can arise as pointed by Berdou (2017) was the restlessness of some people in the community of Kibera, some of them did not appreciate having their shops geolocated since they did not fully knew for what purpose the data was going to be use and they feared that the government would take action against them.

Mapping for change (Corbett et al., 2006) gives a toolbox used in participatory practices, it explains how these different tools and methods are performed and perceive when working in marginalized groups in society. An example worth mentioning is the use of Global Position System among NGOs and community organizations, with the rapid spread of the technology it has become more accessible and organizations now have access to the exact location of different elements in the territory, it is commonly use to draw boundaries in land disputes as well as to add accurancy to information previously collected with community mapping methods (Corbet et al., 2006).

There are several examples of community mapping and PGIS in slums, for instance, Map Kibera has given citizens a spatial perspective of their own community with the help of trained youngsters from the settlement on the other hand there is also the example of enumeration in the informal settlement of Kisumu in Kenya that was made possible by residents and grassroots organizations. The enumeration in Kisumu seeked to provide basic information about the households and more details about the structure of the houses (Karajana, 2010).

A deeper analysis of open development in poor countries made by Berdou (2017) showed that although people contributing in Map Kibera project though that "the training could lift them out of poverty" (Berdou, 2017, pg 24) it did not prevent them for wanting immediate compensation for their time and effort.

One thing that is essential for community projects, specially in informal settlements, is taking the time to build trust among their inhabitants and the local institutions. Also, knowing better the dynamics of the place as well as the expectations of the people involved. Three main subjects are highlighted by McCall et al. (2006) for better practices in PGIS and communitary mapping: transparency in the communication and the process; time, it states that these kind of projects need time to maximized the outcomes and for a real empowerment of the community and ultimately trust, the relation between different groups and individuals depends upon the trust developed through the process.

Mac Chapin in Mapping for Change (IIED, 2006), states that although a community mapping project could have a genuinely participatory approach it does not prevent it to have an undesirable outcome due to the complex relation of citizens and their institutions.

Another approach that can ease PGIS and communitary mapping in slums note by Chapin (2006), is the suggestion that projects of this kind should be treated as a community-based projects, this is due to the fact that if the project is focus in the technicalities it might compromise the engagement of people participating, the people participating in mapping the community should have control over the management and activities. The maps produced by the people involved will be more likely to be used in the future since the process would establish a sense of ownership (IIED, 2006, pg 95).

A reference to this can be seen again in the project of Map Kibera, where the experts trained a group of young people in the use of the tools but did not impose any condition on what to map resulting in "an opportunity to create a picture of the slum life from the ground, as seen by residents themselves" (Hagen, 2011, pg. 6).

On the other hand the experience of Kisumu shows that the people collecting the information is as important at the data collected, the community played a fundamental role for the enumeration project where inhabitants and grassroots organizations where preferred rather than external enumerators. This approach can reveal the data from the perspective of the same inhabitants, it influences, as Karanja noted, " not only the quality and detail of the data collected and its verification but also the nature of the residents" (Karanja, 2010, pg 218).

There are many examples for good practices of data collection that can be implemented in slums yet the conditions of each of the informal settlements, as discussed previously in this chapter, may vary depending on the internal conditions of the area in question.

### **1.3 Research Objectives**

Mapping highly populated areas like slums can be very challenging task, as mentioned previously, community-based mapping projects performed in slums have dedicated much of the work, not only to the outcome itself but to the process. The aim is to build a prototype that complies with the voluntary nature of VGI tools taking into account the good practices of participatory GIS experiences as well as the constraints presented in slum

community-based mapping. The tool should be inclusive, in order to achieve the following objectives:

- It is necessary to establish communication with institutions, associations or organized groups of citizens based in the study area.
- It is necessary to know if a tool of this kind have the real potential to be used in the study area.
- It is necessary to identify the real issues in the territory that will be introduced in the application as possible categories for its collection.

The technical development of the application has several specific objectives:

- Use the embedded GPS system in smartphones to collect the location
- The data will be shown in a map as points
- Simple and clear user interface

### **1.4 Problem Statement and Research Questions**

The previous experiences on slum data collection pointed in this papers have been made in-situ. The projects have been integrated by groups of technicians who have worked in direct contact with organized groups within the communities and have used professional tools for the collection of the data.

A Volunteer Geographic Information tool could optimize the way in which these areas are mapped, the data acquire could be used to accompany internal decision making processes and could facilitate the intervention of municipalities.

Mapping highly populated areas like slums can be a very challenging task for municipalities as well as for experts in the field.

The lack of existing data can lengthen and compromised the possible solutions of issues inside these areas, the possible outcomes could potentially ease slum upgrading transformations.

Informal settlements are complex places and not all share the same characteristics, they can differ in many subjects.

Therefore, the goal of this project is to create a prototype that complies with the technical characteristics described above and takes into consideration the possible feedback from people working and lived inside the studied area. The study leads to the following questions:

- Whether or not VGI-based solutions can help policy makers and urban planners to sense problematic areas especially in the developing world in order to collect relevant data for different purposes?

- How can a VGI prototype be built for slum data collection and how can it be implemented remotely?

- What should be the issues taken in consideration of the area and how they can be implemented in the prototype?

# 2 Methodology

The initial phase of this work tried to conduct a survey taking in consideration as many citizens that lived of work in the area. The first attempt of survey was conducted and sent by email to different organizations located within the area, the type of organization chosen for the first attempt were the municipality, two museums, a baseball sport club for kids and a medical dispensary. All the institutions contacted were located inside the area. The survey did not yield any replies after three weeks.

The second attempt had a more narrowed approach. Through social media it was found two non profit organization working actively in the territory, when contacted both showed interest in the prototype.

The intention of the survey was understand three basic aspects before going further with the selection of the categories and understand if a tool with this characteristic could be, in a first phase introduce by these organizations, and in a future be useful to the community.

In addition, an assessment of Wikimapia was done with 3 different categories. The decision to do an assessment of categories using Wikimapia was made considering it shares concepts with VGI tools and therefore it could provide more information about some of the current features already highlighted in the study area.

### 2.1 Case Study: Petare, Caracas

Petare is the biggest informal settlement in the capital city of Caracas (Ramos et al.,2012) in Venezuela, it is part of Sucre which is the second largest municipally in Caracas situated in

the east of the city, the population as for the census block from 2011 was approx 372.616<sup>1</sup>. Petare holds an estimated of 10 major neighborhoods and it is further subdivided in an estimated of 1,200 mini neighborhoods (Ramos et al., 2012). The boundaries of the informal settlement are established by the ridges of hills and the highway, the space is highly dense and compact.

The dynamics within Petare are far from what it could be expected, state policies from the past have been tolerant since the settlement started to emerge, the national government has provided from building materials to the construction of water pipes, connecting the houses to the public water system (Karst, 1971).

Some old inhabitants have acquire their occupancy rights by former inhabitants but this agreements results from an informal system of rights developed by the same community that everyone seems to respect since many decades (Karst, 1971) contributing to its the massive expansion.

In Karst study from 1971, he already refers to Petare as a place that was getting attention from planners for its potential in *participatory development*.

In the past years, Petare has been incorporating participatory mechanism such as the participatory budgeting<sup>2</sup>, a methodology that lets people directly decide on the most critics matters of the community and take direct action to improve them, managing as well the economical resources provided by the municipality directly by the citizens.

At Petare there are different organizations working to improve the area, from sports associations, social workers, artists and architects. Lately it has become more frequent to see these organizations working with the community to tackled some of the problematics along with their inhabitants. Some of the action that has been going are focused on the recovery of public spaces, the collection of the garbage from the illegal dumps and transforming the spaces into more meaningful places to play and transit.

Many are the problematics, but one that jeopardize the health of the inhabitants are the informal garbage dumps, the collection of garbage is a service that it cannot be taken by granted, the territorial conformation makes the collection of garbage challenging. The

<sup>&</sup>lt;sup>1</sup> Census block 2011

http://www.ine.gov.ve/documentos/Demografia/CensodePoblacionyVivienda/pdf/miranda.pdf

<sup>&</sup>lt;sup>2</sup> <u>http://www.el-nacional.com/noticias/historico/ocariz-petare-sucre-presupuesto-decide-comunidad\_145839</u>

municipally, engaged in the georeferencing all containers with GPS as a solution to mitigate the problem (Ramos et al., 2012) but public information about the result of this project was not found.

Moreover, architects and planners are developing frameworks to improve planning inside the area on topics like sharing waste disposal and limiting the height of some of the constructions. In a study made by architect and GIS professional Giusti de Perez<sup>3</sup> refers to the importance of these tools to answers critical questions about the territory to improve the future location of some of the services.

It can be concluded that for the inhabitants of Petare, participatory methods are known, the municipality has used GPS devices as a solution to identify problems and organizations and NGOs are carrying out activities of great impact in the community using participatory mechanism.

A role that is important when working inside the area is the community leaders, these figures are needed to enter the community, the NGOs work with community leaders to gain trust between their inhabitants. The connections with these associations is a fundamental asset when working remotely. The study of accessibility made by Giusti de Perez in Petare caught the attention of governmental entities that acknowledge the potential of GIS in slum upgrading. Collecting and analysing slum data can be a very complex task, it seems that it could not have been possible to gather the data without the connection to the community leaders from Petare. Community leaders play a significant role in the community and they are more likely to attract more people into the task.

As it can be seen in Fig 2. Petare proportions are vast and diffuse, it is not possible to establish boundaries for some of the neighborhoods that conform the slum.

<sup>&</sup>lt;sup>3</sup> http://www.esri.com/news/arcnews/spring10articles/rosario-giusti-de-perez.html



Fig 2. Map of Caracas with Petare highlighted.

### 2.2 The Target Organizations Profile

HaciendoCiudad<sup>4</sup> is a non profit organization with nine members, the majority with an architectonic background. The aim of this organization is to transform public spaces through street art, motivating people to find solutions to the physical problems in the community and promoting the co-creation of better places inside the informal settlement of Petare. An example of their work has been the improvement of some of the informal garbage dumps by cleaning the space and then painting the walls, these little actions have caught the attention of the community resulting into more people volunteering in this sort of do-it yourself practice.

<sup>&</sup>lt;sup>4</sup> <u>https://www.haciendociudad.org/mision/</u>

The second organization is a non profit organization as well, it is more multidisciplinary and they cover different issues in the territory. The organization currently works with two main projects: the social diners (@alimentasoliedariedad) an initiative that tries to mitigate undernourishment of youngest population inside the area, currently the diners are nine and with the help of organized citizens more are planned to be open.

The second project they are working with is called "The Observatory of the Municipality" where they are already collecting qualitative data inside the area, the project counts with researchers, professors and professionals in a wide range of fields. The member of the organization provided a document that synthesized the work they were already doing, in this document it was highlight the following:

The methodology used by then was qualitative monitoring with focus groups and community census.

The areas of interest covered: health, food security, utilities (public lighting and transport), detected diseases, crime and violence.

### 2.3 The Survey

The survey focused on three main subjects, a selection of question from each subject will be shown later in this section.

- 1. The usage of application like Google Maps
- 2. The critical issues in the territory
- 3. What considerations do they have for thematic maps

The survey was conducted to the members of the organizations, ten respondents in total. The survey contained 16 closed-ended questions and it was conducted in Spanish. It was tested before being sent to the organizations, the answers from the test will be highlighted in the comments of the graphs after the survey example.

The survey was created using Google Forms and it can be found in this link: <u>https://docs.google.com/forms/d/e/1FAIpQLSc6WZxbXB\_uen2n1GU8B3KnsVLIcDA\_7Dj61y9p9</u> <u>UJon-XgAQ/viewform?usp=pp\_url</u> The questions form:

### Cuestionario sobre la disposición de las personas de la comunidad de Petare a los mapas temáticos y uso de aplicaciones móviles para la recolección de datos sobre el territorio

El cuestionario cuenta con 16 preguntas. Lea con detenimiento las preguntas y responda en base a su opinión/conocimiento personal.

El propósito de la investigación es conocer la disposición de las personas, del sector de Petare municipio Sucre ha los mapas temáticos y el uso de aplicaciones como Google Maps. También las carencias físicas del territorio y la disposición de las personas a aplicaciones móviles para la recolección de datos del territorio. Esta investigación es realizada por una estudiante venezolana de la Universidad de Aalborg Dinamarca como parte de la tesis de máster del Departamento de Geoinformática.

Para empezar el cuestionario haz clic en FILL OUT FORM y cuando termines presiona SUMMIT. Gracias!

\*Required

#### 1. ¿Posee usted un teléfono con acceso a internet? \*

El teléfono que posee puede navegar internet con un plan de datos o cuando tiene acceso a una red wifi

Sí

No

#### 2. ¿Usa aplicaciones de entretenimiento en su teléfono celular? \*

En este caso las aplicaciones de entretenimiento se refieren a juegos como por ejemplo candy crush, pokemon go, etc. No se considera Facebook, Instagram y ninguna de las redes sociales como medio de entretenimiento para esta encuesta

🗅 Sí

🗅 No

### 3. ¿Con qué frecuencia utiliza la aplicación Google Maps?

Nunca

Rara vez

- Con frecuencia
- □ Siempre

#### 4. ¿Cómo usa usted la aplicación de Google Maps u otras aplicaciones con mapas? \*

- La uso para buscar direcciones aunque no tenga que dirigirme para ninguna parte
- La uso cuando tengo que dirigirme desde mi ubicación hasta otro sitio

La uso para descubrir lo que está alrededor de un sitio en específico como ej. parques cerca de mi ubicación

Me gusta descubrir nuevos sitios a través de aplicaciones como Google Maps

### 5. Imagine que existiera para su comunidad una aplicación o plataforma que ayudará a

### visualizar los lugares problemáticos de su zona por ej. basura, huecos en la viabilidad, zonas poco alumbradas, etc. ¿Contribuiría usted con esta aplicación aportando información?

Si

No

☐ Tal vez				
6. De los siguientes fac	ctores del territorio	o: señala el nivel de	e crisis de cada u	10 dentro de
omunidad?				
	Nada critico	Poco critico	Muy critico	En crisis
Inseguridad				
Basura				
Areas verdes				
Iluminacion				
Mobiliario Publico				

#### 7. ¿Qué tanto se ve afectado por los siguientes factores del territorio?

	No me afecta	Me afecta poco	Me crea un problema	Me afecta diariamente n estilo de vida
Inseguridad				
Basura				
Areas verdes				
Iluminacion				
Mobiliario Publico				

8. ¿Sabría usted identificar en un mapa los sitios en estado crítico en su comunidad? \*

🗅 Sí

🗅 No

Tal vez

9. ¿Sabría usted identificar en un mapa dónde se encuentran los servicios en su comunidad?

(Hospitales, mercados, transporte, escuelas, áreas verdes, comercios, etc)

No podría identificarlos

Podría identificar los lugares en mi propia calle

Tengo un buen conocimiento de dónde están ubicados los servicios en mi comunidad y en otras áreas

10. ¿Considera usted que tener un mapa detallado de su comunidad podría ayudar la manera en

que se visualizan ciertos problemas de su comunidad y por consiguiente, la manera de resolverlos? Tick all that apply.

	No considero que ayudaría No tengo el conocimiento Considero que podría ayudar a las comunidades pero no entiendo de qué manera Considero un mapa un instrumento necesario de comunicación
11. ¿Es	taría dispuesto a señalar en una mapa, a través de su teléfono, los lugares peligrosos de
su com	unidad si existiera una herramienta que conservará su anonimato?
	Sí No Me da miedo Tal vez No confío de que mis datos estarán seguros
12. Den reflejad localida apply.	tro de su comunidad existen comercios, servicios o sitios de su interés que no se vean los en Google Maps ó en algún otro medio digital de información? Ej. peluquerías de su ad, comercios informales, autoservicios, ambulatorios, mercado de artesanos etc? Tick all that
	Sí No No lo se
13. Sele	eccione el tipo de comunidad donde usted reside en Caracas:
	Vivo dentro de un asentamiento informal (Barrios) Vivo dentro de la zona metropolitana de la ciudad
14. Si c	ontara con una aplicación, que pudiera usar desde su teléfono celular; donde pudiera
introdu de urba posibles	cir información que facilitara a la municipalidad y alcaldías; el desarrollo de buenas prácticas mismo. Ej: ubicar los sitios donde sería recomendable colocar la recolección de la basura, s áreas verdes. ¿Usaría usted ésta aplicación para ayudar a la recolección de datos?
	Si No
15. Con	isidera usted que una página web con un mapa, que muestre de manera dinámica
probler abando constru	nas del territorio como por ej.: huecos en las vías públicas, mala iluminación, áreas nadas. ¿Podría ser útil para los diferentes entes competentes: alcaldías, municipios, ıctoras, compañía de electricidad?
	Sí No
16. Cua	ndo da direcciones a otras personas:
	Da las direcciones con nombres de las calles Da las direcciones utilizando como referencia puntos conocidos por la mayoría de las personas
	Table 1. The questions form sent to the organizations.

Next, it will present a selection of questions for each of the subjects:

11 responses

1. The disposition of the members of the organizations to technology

In this section of the survey the 10 respondents claimed to have a smartphone with internet connection furthermore it was asked as well the frequency of use of application like google maps, see results Fig 3.



### 3. ¿Con que frecuencia utiliza la aplicación Google Maps?

Fig 3. Google maps usage frequency. Never- 1 (test), Rarely- 6, Frequently- 3, Always- 1.

The final question regards in more detail if they will be keen to contribute with a digital platform to pinpoint the deficiencies in the territory, for instance, individuate informal garbage dumps, issues in the public roads like potholes, poorly lit areas to this questions all 10 respondents were positive to contribute with the collection of the data, see Fig 4.

5. Imagine que existiese para su comunidad una aplicación o plataforma que ayudara a visualizar los lugares problemáticos de su zona por ej. basura, huecos en la viabilidad, zonas poco alumbradas, etc. ¿Contribuiría usted con esta aplicación aportando información?



Fig 4. Acceptance of a platform to visualized issues in the territory.

### 2. The critical issues in the territory

It was ask to the respondents the conditions of the following factors in the territory: security, garbage, parks and green areas, public lighting, urban furniture the selection from not critical (blue), slightly critical (red), very critical (yellow), on crisis (green). See Fig 5. The answer not critical (blue) in the following graphic shows the test.



6. De los siguientes factores del territorio: señale el nivel de crisis de cada uno dentro de su comunidad?

Fig 5. Critical factors in the territory. From left to right: security, garbage,

0

green areas, public lighting, urban furniture.

The second question in this section was regarding the ability respondents to identify the critical issues in the territory with a yes, no, maybe selection. 8 respondents replied with yes, 2 maybe, test answer yes. See Fig 6.

To the third questions on if they could identify in a map the services of the community such as hospitals, schools, markets, shops and green areas; 4 respondents claimed that they could identify only the services in the surroundings of their houses and 6 replied that they has a good knowledge of where the services were found in the whole community, plus 1 test answer. See Fig 7.





11 responses

Fig 6. Could you identify in a map the critical issues in your community? Yes - 8, maybe - 2.

# 9. ¿Sabría usted identificar en un mapa dónde se encuentran los servicios en su comunidad? (Hospitales, mercados, transporte, escuelas, áreas verdes, comercios, etc)



Fig 7. Could you identify services in your community? (Hospitals, food markets, transport, schools, green, areas, shops) identify places nearby - 4, good knowledge of the services in the whole area - 6 (plus test)

### 3. Considerations on thematic maps

10. ¿Considera usted que tener un mapa detallado de su comunidad podría ayudar la manera en que se visualizan ...nsiguiente, la manera de resolverlos?



Fig 8. Considerations on thematic maps and how could they be beneficial to visualized and address community issues. A map could help the community, but I don't know how - 4, A map is a fundamental tool - 6 (plus test)

Do you think that having a detailed map of your community could help the way in which certain problems of your community are visualized and therefore, how to address them? - I consider it would help the community but I don't know how - 4, I consider maps useful instruments - 6, plus 1 test answer. See Fig 8.

Furthermore, in this sections it was ask *Would you be willing to point out on a map, through your phone, the dangerous places of your community if there was a tool that would preserve your anonymity?* Where 7 respondents replied yes (plus 1 test answer), 1 I'm afraid, 1 maybe, 1 I do not trust that my information will be save, see Fig 9.



Fig 9. Would you be willing to point out on a map, through your phone, the dangerous places of your community if there was a tool that would preserve your anonymity?

Within your community there are shops, services or sites of your interest that are not reflected in Google Maps or any other digital map? E.g hairdressers in your locality, informal shops, self-services, daily hospitals, artisan markets etc? Fig 10.

12. Dentro de su comunidad existen comercios, servicios o sitios de su interés que no se vean reflejados en Google Maps ó en algún otro medio digital de información? Ej. peluquerías de su localidad, comercios informales, auto-servicios, ambulatorios, mercado de artesanos etc?



Fig 10. Non existing services in Google Maps of any other digital Map. Yes - 4, No -3, Maybe -3 (plus test)

*Select the type of community where you reside in Caracas:* 5 replied to lived inside the informal settlement of Petare and 5 in the metropolitan city. See figure 11 :



13. Seleccione el tipo de comunidad dónde usted reside en Caracas: 11 responses

Fig 11. Select the type of settlement you live in. Informal Settlement of Petare - 5, Metropolitan City - 5 (plus test)

If you had an application, which you could use from your smartphone; where you could introduce information that could facilitate the municipality with data. Eg: locate the sites where it would be advisable to place the garbage collection, possible green areas. Would you use this application to help with data collection?

All respondents were positive to contribute with the data collection.

Consider a web page with a map that dynamically shows problems of the territory such as: gaps in public roads, bad lighting, abandoned areas. Could it be useful for the different competent entities: city halls, municipalities, construction companies, electricity company? All respondents agreed that could be useful.

The second step after the survey was to decide the issues in the territory together with the organizations, it was necessary to delimited the number of categories due to the time frame of the investigation. It was decided three initial categories to start building the prototype.

It was also discussed with the members of both organizations that although they were deciding on the categories and possibly basing the decision on their own work, the tool did not pretend to be for the exclusive use of these organizations.

To both of the organizations it was sent a document containing to maps from Map Kibera Project to help the members of the organization to visualize the potential of the tool and how the features will be seen in the map.



Fig 12. Image with comments sent to the members of the organization in Petare as backup material for health center.



Fig 13. Image with comments sent to the members of the organization in Petare

as backup material for security.

Finally the organizations decided what features they decide to be added in the prototype. HaciendoCiudad decided that they would want to use the application to point the locations of their artwork alleging that this would attract more people to join as volunteers especially youngsters. The tool could potentially highlight positive features of Petare that could reinforce the sense of belonging.

The Observatory of the Municipality decided that they would want to use the application to point health centers and crime, they provide documentation from the organization that help to categorize the different types of health centers and also the type of crime they wanted to visualized.

The members of the organization had doubts about the cost that would imply producing an application of this gender. Therefore open source tools were used for the implementation to reduce the cost.

A final proposal was sent, were it was showed how the data would be showed in the map. It was decided that for this first phase of the project it would only be use point data, the tool would only collect the location with a simply and restricted selection of categories.

### 2.4 A contrast of some categories from the study Area with Wikimapia

A complementary investigation was carried in the study case area. Wikimapia <sup>5</sup> was selected since it is a collaborative mapping project where users can add geographical objects with a description. Wikimapia provides a wide range of categories for users to select when adding the objects into the map.

For the analysis it was selected 3 categories, the purpose of this is to check the information that has already been added in the study area.

The three categories selected were: Hospitals, Schools and Garbage.

<sup>&</sup>lt;sup>5</sup> http://wikimapia.org



Fig 14. Category garbage from Wikimapia showing no results.



Fig 15. Category Schools.



Fig 16. Category Hospitals.

# 3 Implementation

### 3.1 The Web Application

The web application have been implemented using different components, this chapter will explain the structure of the application and its functions.



Fig 17. Application process overview

To start collecting data it is necessary to open the url, the map will open and it will show a menu where two options are presented. First, it is possible to press save location where it will be presented a set of categories, the selection of category is done by checking the box, to go further click on next and the menu will present a set of classes or subcategories, these classes will be selected by checking the box as well, then by pressing continue the data will

be save. When saving location, it is only possible to select one category and one subcategory. The second option in the menu will show the saved locations on the map, in this case, it is possible to select different types of categories at the same time as well as subcategories.

As it can be seen in Fig 17, once the save location bottom is selected it contains the following categories: health, art and crime. Selecting one of these categories, it will show the classes or subcategories, each categories is followed by one or more of these. The element health contains, as well, another selection by the name status; it will allow the user to report the conditions of the health service by selecting: operational, closed, no operational. The category art, as requested by the one of the organizations previously mentioned, will only enclose street art for now.

As for crime it will be followed by the classes: robbery, kidnapping, shooting. It will allow the users to report the places where this type of crime tends to happen more frequently.



Fig 18. Menu overview

The menu implementation has two types of buttons. The button save location is radio type allowing only to check one category, as for show map it was used a checkbox implementation allowing all features to be checked and show in the map. Fig 19.



Fig 19. First image showing checkbox with all categories selected in show on the map,second imagine radio only one category checked to add data.

### 3.2 Map

To render the map it was use Mapbox GL JS. A JavaScript library for building web applications. To use the map styles from Mapbox it was necessary to create a token, the token will connect with the APIs from Mapbox and retrieve the information of the map. The style selected to render the basemap was the satellite map due to its high resolution.



Fig 20. Zoom level 16



Fig 21. Zoom level 17

The map center is setup to open automatically in the study case area (starting position) show in Fig 22 and the start zoom level is 16. The map.addcontrol adds zooming and rotation to the map. The function draw adds the markers for each category to the map and the mapboxgl .Marker shows the pop-up for each category with their description.

```
mapboxgl.accessToken =
'pk.eyJ1IjoibXBnYSIsImEiOiJjamRyOXE3ZzcwaXRpMnhxeWR4MHYyaWU1In0.hDGHqHJTgQdooeO
/* eslint-disable */
var map = new mapboxgl.Map({
    style: 'mapbox://styles/mapbox/satellite-v9', //hosted style id
    center: [-66.8015500, 10.4722600], // starting position
    zoom: 16 // starting zoom
});
// Add zoom and rotation controls to the map.
map.addControl(new mapboxgl.NavigationControl());
var el;
function draw(){
 if((sl==true))|(sd==true)){
  // add markers to map
 draws.features.forEach(function(marker) {
   //create a HTML element for each feature
```



Fig 22. Part of the html that renders the map and its functions.

### 3.3 Database

As for the database, it was chosen to work with postgresql for being open source and the ease of handling geographical data.

The schema points of the database contains three tables, one table for each category added.

The table health contains an id as primary key, a unique identifier for each row in the table (Postgres). The pname column which is the name the user will give to each of the objects saved in the map, the coordinates will be storage as a point type, the classification is a subcategory in which the user will select the different types of health centers in the territory. The table health is the only table that contains status, from the menu the user will select the condition of the different types of health center. See Fig 23.

```
create table points.health (
id int PRIMARY KEY,
pname text,
coordinate point,
classification text,
```



For the categories art and crime the tables were identical created. See Fig 24.

```
create table points.art (
id int PRIMARY KEY,
pname text,
coordinate point,
classification text,
);
```

Fig 24. The structure of table art that shares the same values as table crime.

### 3.4 The Server Side

The connection to the server side was made using PHP language, as the web application is highly dynamic and interactive. The Fig 25 shows the backend connection to the postgresql database using php.

```
<?php
Class dbObj{
    /* Database connection start */
    var $servername = "localhost";
    var $username = "postgres";
    var $password = "123";
    var $dbname = "postgres";
    var $dbname = "postgres";
    var $port = "5432";
    var $conn;
    function getConnstring() {
    $dbconn = pg_connect("host=".$this->servername." port=".$this->port."
    dbname=".$this->dbname." user=".$this->username."
    password=".$this->dbname." user=".$this->username."
    password=".$this->password."") or die("Connection failed: ".pg_last_error());
    /* check connection */
    if (pg_last_error()) {
        printf("Connect failed: %s\n", pg_last_error());
    }
}
```

```
exit();
} else {
   $this->conn = $dbconn;
}
return $this->conn;
}
}
```



When the user saves a new location in the map it will be automatically storage in the database following the pre-set criteria for each category. Using pg\_escape\_strig() enables the php script to be readed as a variable instead of a string facilitating the query of the database. See Fig 26.

```
<?php
include("includes/connection2.php");
$iddb = $_POST['iddb'];
$iddb = pg escape string($iddb);
$pnamedb = $_POST['pnamedb'];
$pnamedb = pg_escape_string($pnamedb);
$coordsdb = $_POST['coordsdb'];
$coordsdb = pg_escape_string($coordsdb);
$classificationdb = $_POST['classificationdb'];
$classificationdb = pg escape string($classificationdb);
$categorydb = $_POST['categorydb'];
switch ($categorydb) {
      case "salud":
             $statusdb = $_POST['statusdb'];
             $statusdb = pg escape string($statusdb);
             $sql="INSERT INTO points.health
(id, pname, coordinate, classification, status) VALUES
('{$iddb}','{$pnamedb}','{$coordsdb}','{$classificationdb}','{$statusdb}')";
             pg_query($dbconn,$sq1);
             break;
      case "crimen":
             $sql="INSERT INTO points.crime
(id, pname, coordinate, classification) VALUES
('{$iddb}','{$pnamedb}','{$coordsdb}','{$classificationdb}')";
             pg_query($dbconn,$sql);
```



Fig 26. Inserting values into the tables..

### 3.5 Client Side

As for the client side of the web application it was use JavaScript language to build the dynamic objects of the map, like the menu. As well as HTML to render the functions of the map and CSS to style it.

It was decided in the development of the tool that no framework was going to be used, this is due to the fact that the stability of the application might be compromise if the framework is subjected to changes in the future.

To the menu it can be added new categories whenever it is requested from the users, it is expected that with more people using the tool more features will be required in the future.

The creation of the menu, which is an essential part of the web application was developed with the collaboration of a first year of Computer Engineering student of the Catholic University Andres Bello of Caracas, Venezuela.

The code of the menu is extensive and it will be included for further reading in the appendix.

# **4** Results and Discussion

### 4.1 Results

The interview was conducted in order to know if non-profit organizations or other emerging organizations in the area would be interested in using tools to capture geographic data. The first relevant argument that needed to be investigated before going further with the details of the project was to know if the participants had smartphones. The results from the survey showed that the ten respondents have a smartphone and mobile data. It was fundamental to break the survey into three main subjects, the first one was focused on the use of applications like Google Maps and for what it was use. Among the options, respondents could select if they use it to search for locations even if they did not have to go anywhere, to navigate from point A to point B, discover points of interest in the surroundings or discover remote places for fun.

The majority of respondents alleged that they used rarely applications like Google Maps and most of them use the application only to navigate from point A to point B. The second section of the survey was focused on the critical issues in the territory, the survey intended to seek for patterns and reinsure the information previous consulted for the case study.

The considerations from the respondents to the critical issues in the informal settlement of Petare pointed the following: lighting and public spaces as the first variable, following by crime, parks and green areas, garbage and public furniture.

The majority of the respondents allege that their daily routine was compromise mostly by public lighting and crime.

Furthermore, it was asked if they could identify the location of the issues aforementioned on a map, among the three given options respondents chose two answers: the majority could

identify hospitals, open markets, schools, green areas and shops not only inside Petare but in other areas of the city, the rest of the answers pointed that they could identify the same services only in the surroundings of their own houses.

As for the considerations on thematic maps, the majority agreed that having a map was a necessary tool for visualizing problems in the community and that it could help the way the problems are address, the other four replies agreed that maps were necessary but they were not sure how it could help.

The respondents were willing to cooperate in the collection of crime data, the majority of the answers were positive with one respondent that allege being scared and other one was concern on the security of their information.

Half of the participants live inside the informal settlement of Petare while the other half live in the metropolitan area.

Finally, it was asked if they would be willing to collaborate with an application that could capture the location of different issues in the territory and could be use through their smartphones, all respondents agreed.

Furthermore, from the communications held it was possible to know in more detail which were the issues they wanted to highlight for the prototype. In this stage it was fundamental to give more information about how GIS work and the benefits of using these tools. Geographic Information Systems are rare in this particular case study area and it was new to the majority of the members of the organizations.

The members were positive to collaborate with new additions for the categories such as adding a layer to identify the illegal garbage dumps and social diners in the future. It was interesting to notice that the members of the organization shared the idea of an open tool that could be use in the future, not only by them, but by residents of the community as well.

As for the decision to add street art, which is not considered to be a critical issue in the community, was based on the assumption that a layer highlighting positive interventions would call the attention of the people of the community as well as other organizations in the territory. The organization that decided to highlight their artwork in the community alleged that it could lift the sense of belonging.

The other two selected categories are of fundamental importance for the *Petare Community Observatory Project*, since they already work with the collection of qualitative information, the tool could accompany their current work.

It is not determined if the crime layer should be reformulated to be used only by the association and not be public, the consequences that could bring to the community should be studied carefully in the future.

The study would have preferred that the survey had reached not only non profit organizations but also inhabitants that are not part of these. The restrictions of time, resources and distance did not allow reaching a larger sample. It is clear that, to permeate into community, especially for remote collaboration projects, it is necessary to contact these organizations.

As for the the comparison made with Wikimapia, it tried to show that, although layers such as health and schools did show some results in the interest area, it is not possible to answers more detail questions about the state of these, the capacity, status or other variables that can be use to bring insights. Another layer was consulted, the category *criminal* in Wikimapia did not show any results. This is of particular interest since it is a real problem inside the area, having subcategories of the type of crime committed could help the community to identify and visualized the dangerous zones, it could be useful for the municipality to have this information.

### 4.2 Discussion

The first aspect noticed in the initial phase of this work was the need to confirm information related to the area, do to so it was necessary to search for the institutions located inside the informal settlement of Petare, contact them and explain the purpose of the research. Some of the institutions contacted first have great visibility in the territory, they are related in some cases to local administrations. A few of these institutions replied and agreed to help spreading the survey among their contacts, the results showed little participation in the

survey. The complications related to the communication flow and how to engage people in the research were noticed in this first stage.

The use of social media to identify non-profit organizations turns out to be very useful, through this channel it was noticed the proliferation of these in the case study area and opened another perspective to the research. The idea that for the tool to have visibility could be introduced, in a first stage, by these associations.

After the contact was made, it was necessary to explain in detail how these tools worked, the nature of volunteering while using crowdsource for data collection. It was not share with the members the technical work behind the development of the application, this was decided considering the suggestions made by Mac Chapin in Mapping for a Change (1.2). The worked focused more in establish a stable communication backed up with information related to GIS and examples of different mapping projects that could be related to the issues in Petare. Examples of the outcome of Map Kibera Project were sent in addiction to other documentation that could help the members to understand better the purpose, the benefits and the outcomes. This reveal the importance of considering designing and producing custom documentation for future use. The importance of using materials and documentation can also be related to the practices of PGIS and communitary mapping. The idea of involving the members in the selection of the categories for the map also shares similarities with the good practices of the aforementioned techniques, where the participants are in the center of the process.

The nature of the organizations and the background of the members also played a significant role. The majority of the members of HaciendoCiudad were architects and urban planners, their work aims to recover public spaces inside these communities leaning on concepts like active citizenship, ephemeral architecture and applying participatory mechanisms inside the community. This changed the perception regarding the use of the application and how it could be introduce in the community. One of the positive revelations was that indeed the tool could be use to highlight positive interventions in the community, not only for the purpose of one organization but it should be inclusive for the work of anyone.

It could be noticed in the results that the daily routine of the participants was affected by the poor public lighting and the high rates of crime, the tool could produce a possible correlation between the poor lighting areas and the location of the crimes.

The considerations on whether the tool could be useful for the municipality and other local institutions can be assumed, the fact that the no official data is available to the public was a constraints for the implementation of the data into the database, without a formal framework was not possible to emulated an official structure. The critical issues in the territory, that have been critical for several years as pointed by Ramos (2012) can be an opportunity for a tool with this characteristics and a technological approach might result beneficial for the municipalities.

The technical considerations throughout the study were also an important factor, since the beginning, it was decided to use only open source to develop the prototype and lessen the costs of production. The difficulty that arose in the development of the web application was mostly related to the development of the menu as the technical expertise was not up to the task at the beginning of the implementation, thus, it was needed external collaboration to complete some of the technical aspects of the menu. Another concern worth to mention is the cost of Mapbox services, the platform offers a free plan for up to 50,000 views after the number is exceeded the service offers a pay-as-you-go plan. Only the testing of the prototype in the implementation phase results on almost 2,000 views what leads us to think that another service might worth to look at.

Although the prototype was tested several times in the implementation, it was not tested by the organizations, otherwise it would have been considered further interviews to collect suggestions and feedback for future improvements.

It can be argued that the tool complies with the VGI conditions stipulated by experts in the area, at it current state the prototype is free to use and is not tied to any organization. It must also be recognized that the implementation tried to introduced some practices of PGIS and community mapping techniques, where the people involved in the process decides what is important to map and why is important. The future of the prototype will depend on the participation and the addition of volunteers, the organizations can contribute with suggestions for new categories and the information that would be collected with the point

data, in this way, both parties can benefit without compromising the openness and transparency of the tool and the process. Moreover, the tool proved to be useful to complement the work of both organizations. Although the selection of the categories was made by a very small sample and it cannot be considered as representative for the inhabitants of Petare, they can still be beneficial for the community. The decision was successful and mirrors some of the real problems the area faces. The threats that the project may have were also considered, external problems related to political instability or services malfunctions can sabotage the communication and the use of the tool. As well, it cannot be assumed that the collaborators or future volunteers will want to spend their data plans collecting points, it is included in the list of future developments the possibility to save the location offline and added later when the connection is re establish. Another factor that can compromise the use of the prototype is the dependency of these organizations, that can easily be detached from the process.

The use of open source can lessen the costs of production, if the tool turns out to be successful in the community it might need to rely on pay services for the storage. Crowdsource applications for reporting violence, like *Ushahidi*, have been implemented in Kenya and although it follows the concepts of Volunteer Geographic Information, the most of the features presented for surveying are not offered for free. A possible solution could be rely on future contributions for the continuing development of new features.

To implement VGI for slums, even remotely it is necessary to take into consideration the practices of community-based and PGIS projects, involving the community might take longer than practices done in-situ that is why collaboration with groups of active citizens is necessary. The use of social media to spread the prototype could help the increase in users and could attract the attention of citizens and municipalities.

The success of VGI for slum data collection can lean on the mechanism used in community mapping and PGIS, specially care need to be put in the process and the communication.

### **4.2** Future Development

The web application at it current state has limited categories and subcategories that might need to be sort out differently in the future, this will depend on the usage and the suggestions of the users. It will be taken in consideration to add a suggestion form that will allow users to help with the development of the tool itself.

For now the tool do not count with a login for the users, the way users login has to be further study, a possibility could be a simple form where users insert a username and a password without the need of using an email address for security reasons.

The user interface in it current state is easy but with the increase in the categories and subcategories the menu might change to improve the way users add data. As well as the creation of custom icon for the different categories could be a possibility to make the tool more appealing.

Once the tool will have a sufficient amount of data stored it will be study the implementation of processing tools for a better visualization, where users can chose parameters to see patterns in the map.

It has been considered further studies in the field of geogaming to make the application more friendly to the users, especially younger people in the community.

Offline mapping

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### Appendix

### Menu implementation

```
var n = 0;
var sl = false:
var sd = false;
var menuids = ["menu0","menu1","menu2","menu3","menu7"];
var menuids2 = ["menu0","menu4","menu5","menu6","menu8"];
function showdat(){
 sd = true;
 next();
}
function saveloc(){
 sl = true;
 next();
}
function next(){
 if((n>=menuids.length-1)||(n>=menuids2.length-1)){
  if(sd == true)
    n = menuids.length-1;
  }else{
    n = menuids2.length-1;
  }
 }else{
  n++;
  menu();
 }
}
function prev(){
 if(n<=0){
  n = 0;
  menu();
 }else{
  n--;
  menu();
 }
}
function arrmenu(){
 if(sd == true){
  for(i=0;i<menuids.length;i++){
  document.getElementById(menuids[i]).style.display = "none";
 }
 }else{
  for(i=0;i<menuids2.length;i++){
  document.getElementById(menuids2[i]).style.display = "none";
  }
 }
}
function menu(){
 arrmenu();
 switch(n){
```

```
case 0:
 sl = false;
sd = false;
 indexh =[];
 indexa =[];
 indexc =[];
 draw();
 document.getElementById("menu0").style.display = "block";
 document.getElementById("buttons").style.display = "none";
 for(i=0;i<document.getElementsByTagName("input").length;i++){
  document.getElementsByTagName("input")[i].checked = false;
 }
 break;
case 1:
 if(sd == true)
  document.getElementById(menuids[1]).style.display = "block";
  document.getElementById("buttons").style.display = "block";
 }else{
  document.getElementById(menuids2[1]).style.display = "block";
  document.getElementById("buttons").style.display = "block";
  pos();
 }
  break;
case 2:
 if(sd == true)
  document.getElementById(menuids[2]).style.display = "block";
  if(document.getElementsByName("categoria")[0].checked == true){
   for(i=0; i<document.getElementsByClassName("health").length; i++){
    document.getElementsByClassName("health")[i].style.display = "inline-flex";
   }
  }else{
   for(i=0; i<document.getElementsByName("health").length; i++){
    document.getElementsByName("health")[i].checked = false;
   }
  }
  if(document.getElementsByName("categoria")[1].checked == true){
   for(i=0; i<document.getElementsByClassName("art").length; i++){
    document.getElementsByClassName("art")[i].style.display = "inline-flex";
   }
  }else{
   for(i=0; i<document.getElementsByName("art").length; i++){</pre>
    document.getElementsByName("art")[i].checked = false;
   }
  }
  if(document.getElementsByName("categoria")[2].checked == true){
   for(i=0; i<document.getElementsByClassName("crime").length; i++){
    document.getElementsByClassName("crime")[i].style.display = "inline-flex";
   }
  }else{
   for(i=0; i<document.getElementsByName("crime").length; i++){
    document.getElementsByName("crime")[i].checked = false;
   }
```

```
}
if(document.getElementsByName("categoria")[0].checked == false){
 for(i=0; i<document.getElementsByClassName("health").length; i++){
   document.getElementsByClassName("health")[i].style.display = "none";
  }
 }
if(document.getElementsByName("categoria")[1].checked == false){
 for(i=0; i<document.getElementsByClassName("art").length; i++){
   document.getElementsByClassName("art")[i].style.display = "none";
  }
}
if(document.getElementsByName("categoria")[2].checked == false){
 for(i=0; i<document.getElementsByClassName("crime").length; i++){
   document.getElementsByClassName("crime")[i].style.display = "none";
  }
 }
}else{
document.getElementById(menuids2[2]).style.display = "block";
if(document.getElementsByName("categoria")[3].checked == true){
 for(i=0; i<document.getElementsByClassName("health").length; i++){
   document.getElementsByClassName("health")[i].style.display = "inline-flex";
  }
 }else{
 for(i=0; i<document.getElementsByName("health").length; i++){
   document.getElementsByName("health")[i].checked = false;
 }
 }
if(document.getElementsByName("categoria")[4].checked == true){
 for(i=0; i<document.getElementsByClassName("art").length; i++){
   document.getElementsByClassName("art")[i].style.display = "inline-flex";
  }
}else{
 for(i=0; i<document.getElementsByName("art").length; i++){
   document.getElementsByName("art")[i].checked = false;
  }
 }
if(document.getElementsByName("categoria")[5].checked == true){
 for(i=0; i<document.getElementsByClassName("crime").length; i++){
   document.getElementsByClassName("crime")[i].style.display = "inline-flex";
  }
}else{
 for(i=0; i<document.getElementsByName("crime").length; i++){
   document.getElementsByName("crime")[i].checked = false;
  }
 }
if(document.getElementsByName("categoria")[3].checked == false){
for(i=0; i<document.getElementsByClassName("health").length; i++){
 document.getElementsByClassName("health")[i].style.display = "none";
 }
}
if(document.getElementsByName("categoria")[4].checked == false){
for(i=0; i<document.getElementsByClassName("art").length; i++){
```

```
document.getElementsByClassName("art")[i].style.display = "none";
  }
 }
  if(document.getElementsByName("categoria")[5].checked == false){
  for(i=0; i<document.getElementsByClassName("crime").length; i++){
   document.getElementsByClassName("crime")[i].style.display = "none";
  }
 }
 }
  break;
case 3:
if(sd == true)
  if(document.getElementsByName("categoria")[0].checked == true){
   document.getElementById(menuids[3]).style.display = "block";
   for(i=0; i<document.getElementsByClassName("status").length; i++){
    document.getElementsByClassName("status")[i].style.display = "inline-flex";
   }
  }else{
   document.getElementById(menuids[3]).style.display = "block";
   for(i=0;i<document.getElementsByName("status").length;i++){
    document.getElementsByName("status")[i].checked = false;
    document.getElementsByClassName("status")[i].style.display = "none";
   }
   alert('Debe seleccionar "Salud" en el primer menú para tener acceso a esta opción');
  }
 }else{
  if(document.getElementsByName("categoria")[3].checked == true){
   document.getElementById(menuids2[3]).style.display = "block";
   for(i=0; i<document.getElementsByClassName("status").length; i++){
    document.getElementsByClassName("status")[i].style.display = "inline-flex";
   }
  }else{
   document.getElementById(menuids2[3]).style.display = "block";
   for(i=0;i<document.getElementsByName("status").length;i++){
    document.getElementsByName("status")[i].checked = false;
    document.getElementsByClassName("status")[i].style.display = "none";
   }
   alert('Debe seleccionar "Salud" en el primer menú para tener acceso a esta opción')
  3
 }
break;
case 4:
if(sd == true)
 document.getElementById(menuids[4]).style.display = "block";
 document.getElementById(menuids[3]).style.display = "none";
 document.getElementById("buttons").style.display = "none";
 }else{
 document.getElementById(menuids2[4]).style.display = "block";
 document.getElementById(menuids2[3]).style.display = "none";
 document.getElementById("buttons").style.display = "none";
 document.getElementById("lugarsub").style.display = "block";
```

```
}
break;
}
}
```

### Maps functions

var indexh =[]; var indexa =[]; var indexc =[]; var classificationdb; var pnamedb; var statusdb; var iddb; var coordsdb; var categorydb; var draws = {"type": 'FeatureCollection',"features": []}; var inputlog = document.getElementsByTagName("input"); function tablehealth(){ for(i=0; i<indexh.length;i++){ var x = tablepointsh[indexh[i]].coordinate; x = x.slice(1,(x.length-1));var comma = x.indexOf(","); var coordinatex = x.slice(0,comma); var coordinatey = x.slice(comma+1, x.length); coordinatex = parseFloat(coordinatex); coordinatey = parseFloat(coordinatey); draws.features.push({ "type":'Feature', "geometry": { "type": 'Point', "coordinates": [coordinatex, coordinatey] }, "properties":{ "title": tablepointsh[indexh[i]].classification, "description": tablepointsh[indexh[i]].status, "place": tablepointsh[indexh[i]].pname, "icon": 'hospital' } }) }

#### }

}

```
function tableart(){
 for(i=0; i<indexa.length;i++){
  var coordinatexy = tablepointsa[indexa[i]].coordinate;
  coordinatexy = coordinatexy.slice(1,(coordinatexy.length-1));
  var comma = coordinatexy.indexOf(",");
  var coordinatex = coordinatexy.slice(0,comma);
  var coordinatey = coordinatexy.slice(comma+1, coordinatexy.length);
  coordinatex = parseFloat(coordinatex);
  coordinatey = parseFloat(coordinatey);
  draws.features.push({
   "type":'Feature',
   "geometry":{
     "type": 'Point',
     "coordinates": [coordinatex, coordinatey]
   },
   "properties":{
     "title": tablepointsa[indexa[i]].classification,
     "place": tablepointsa[indexa[i]].pname,
     "description": " ",
     "icon": 'art-gallery'
   }
  })
 }
function tablecrime(){
 for(i=0; i<indexc.length ;i++){</pre>
  var coordinatexy = tablepointsc[indexc[i]].coordinate;
  coordinatexy = coordinatexy.slice(1,(coordinatexy.length-1));
  var comma = coordinatexy.indexOf(",");
  var coordinatex = coordinatexy.slice(0,comma);
  var coordinatey = coordinatexy.slice(comma+1, coordinatexy.length);
  coordinatex = parseFloat(coordinatex);
  coordinatey = parseFloat(coordinatey);
  draws.features.push({
   "type":'Feature',
   "geometry":{
     "type": 'Point',
     "coordinates": [coordinatex, coordinatey]
```

}

```
},
    "properties": {
     "title": tablepointsc[indexc[i]].classification,
     "place": tablepointsc[indexc[i]].pname,
     "description": " ",
     "icon": 'triangle-stroked'
    }
  })
 }
function tableindexes(){
 for(i=0; i<inputlog.length; i++){</pre>
  if(inputlog[i].checked == true){
    for(j=0; j<tablepointsh.length; j++){
     if(tablepointsh[j].status == inputlog[i].value){
      indexh.push(j);
     }
    }
    for(j=0; j<tablepointsa.length; j++){</pre>
     if(tablepointsa[j].classification == inputlog[i].value){
      indexa.push(j);
     }
    }
    for(j=0; j<tablepointsc.length; j++){</pre>
     if(tablepointsc[j].classification == inputlog[i].value){
      indexc.push(j);
```

```
}
   }
  }
 }
}
function enviar(){
 tableindexes();
 tablehealth();
 tablecrime();
 tableart();
 draw()
}
function pos(){
 navigator.geolocation.getCurrentPosition(
    function(position){
        var lat = position.coords.latitude;
        var long = position.coords.longitude;
        map.flyTo({center: [long , lat]});
        coordsdb = "(" + long + "," + lat + ")";
    });
}
function poss(){
 if(document.getElementsByName("categoria")[3].checked == true){
  categorydb = "salud";
  for(i=0; i<document.getElementsByName("health").length; i++){
   if(document.getElementsByName("health")[i].checked == true){
    classificationdb = document.getElementsByName("health")[i].value;
  break;
   }
  }
  for(i=0; i<document.getElementsByName("status").length;i++){
   if(document.getElementsByName("status")[i].checked){
    statusdb = document.getElementsByName("status")[i].value;
  break;
```

```
}
  }
   iddb = tablepointsh.length + 1;
   pnamedb =document.getElementById("lugarsub1").value;
 }
 if(document.getElementsByName("categoria")[5].checked == true){
  categorydb = "crimen";
  for(i=0; i<document.getElementsByName("crime").length; i++ ){</pre>
   if(document.getElementsByName("crime")[i].checked == true){
    classificationdb = document.getElementsByName("crime")[i].value;
   }
  }
   iddb = tablepointsc.length + 1;
   pnamedb =document.getElementById("lugarsub1").value;
 }
 if(document.getElementsByName("categoria")[4].checked == true){
  categorydb = "arte";
  for(i=0; i<document.getElementsByName("art").length; i++){
   if(document.getElementsByName("art")[i].checked == true){
    classificationdb = document.getElementsByName("art")[i].value;
   }
  }
   iddb = tablepointsa.length + 1;
   pnamedb =document.getElementById("lugarsub1").value;
 }
 if((iddb!= "")&&(pnamedb!= "")&&(coordsdb!="")&(classificationdb!="")){
   pass();
  }else{
   alert("Faltan datos");
   location.reload();
  }
}
function pass(){
 var parms = {
  "iddb" : iddb,
  "pnamedb" : pnamedb,
  "coordsdb" : coordsdb,
  "classificationdb" : classificationdb,
  "statusdb" : statusdb,
```

```
"categorydb" : categorydb
 };
  $(function(){
   $.ajax({
    type: 'post',
    url: 'StoreDatah.php',
    data: parms,
    async: false,
    success: function(){
      alert("Guardado satisfactoriamente")
    },
    error: function(){
      alert("Acción no completada")
    }
   });
  });
}
```