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MSC GEOINFORMATICS  
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# **HUMANITARIAN GIS**

Exploring the role of participatory Web GIS for disaster response

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## **ABSTRACT**

During natural disaster emergencies with damaging impact to urban infrastructure, the widespread of data helps deployment of relief in extremely time-sensitive situations. This paper reviews the research and development process of implementing a Web GIS application prototype designed to facilitate information sharing during response phases to natural disaster crises. Further, it adds the possibility of integration and user base expansion, by involving the public into collaborating through social media within the same application. Also, the relevancy of public collaboration and VGI is discussed alongside with the challenges of interoperability of data when using different sorts and formats of the latter in Web GIS solutions.

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## **Introduction**

In disaster situations, rapid access to informative and relevant data can be decisive in saving lives and preventing further casualties. During emergencies of natural disaster with damaging impact to urban infrastructure, information widespread alongside constant updating help deployment of relief and informs the community involved. Thus, it facilitates the work of authorities and organizations coordinating efforts to assign to disaster response at the specific outbreak area. With geographical information, pinpoint location and mapped risk zones have made easier for governments not only to assess crisis action with decision making, but also to include the public by sharing the risks of natural disasters.

Further, Geoportals and Web GIS applications can be set to comprehensibly display attentive and relevant infrastructural and geographical data of a specific affected area, considering local data availability.

This paper aims to discuss the process of developing an open-source Web GIS prototype, which displays relevant open source data from governmental and volunteered sources channeled towards emergency crisis response, specifically in Valparaíso, Chile – due to the high occurrence of natural disasters in the area. Moreover, the Web GIS methodology of best practices and the feasibility of data interoperability in open source platforms will be discussed. The facilitating of relief deployment for field workers who do not necessarily count on GIS specialists will be extensively discussed as well, acknowledging the relevance of user experience and proposed user-friendliness of Web GIS as an advantage for systems designed to aid disaster cycle processes.

Subsequently, the inclusion of Web GIS updates for disaster management through social media and VGI interaction is reviewed as an implementation possibility, broadening usability to a larger targeted user group.

## *Research Questions*

This thesis' research questions aim to differentiate the spectrum of this research by the aspects tackled within the development and literature review of this application prototype in particular. Further, these questions aid in delimitating the area of analysis, as there are several probing areas within humanitarian and disaster GIS.

- *How can different data sources be integrated in a WebGIS application for disaster response?*

The main research question refers to characteristics on the relevant data used in the context of GIS in disaster response and how this data is different from general geographical data used for other purposes. Further, it touches upon the interoperability and display of information sourced from different institutions or volunteers.

- *How can a WebGIS application address humanitarian needs with data from different sources, being accessible and interactive to the low-entry targeted user level?*
- *How can a humanitarian WebGIS application be constantly (and relevantly) updated by integrated public sourced data?*

## Background

This chapter aims to set the background for the argument backing up the development and discourse of the proposed WebGIS prototype, alongside with the context setting for further understanding. Additionally, relevant topics such as public collaboration and VGI will be presented, narrowing the scope of this thesis within the large field of disaster GIS.

### *GIS role in the Humanitarian context*

Geographical Information systems and their vast application possibilities made the increase of covered mapped information in areas affected by human made and natural disasters possible, where relevant source and field data are oftentimes scarce. New technologies and data may be combined with more traditional data sources conveying joint useful information in software or web based platforms. Specifically in humanitarian contexts, this conveyed free information could be vital to address areas that are in many instances insufficiently covered by administrative spatial data sources or during emergencies when relief deployment and action management are exceptionally time-sensitive.

Disaster situations can be approached as the intersection between the physical and the social rapidly developing situation on the ground, which can be eminently represented as information in the GIS context (Crooks et al, 2012). Hence, represented spatial data on GIS platforms in disaster areas can simplify and simulate the physical and emergency conditions, on which the decision making process for emergency relief can be based on due to quick data comprehension. Much before spatial data and information were handily shared on the Internet, the assessment of technology development to natural hazard aid already was part of the discussion during the *International Decade for Natural Disasters Reduction* between 1990 and 2000, designated by the United Nations General Assembly. Its primary goal relies upon the perception of the latent need of further cooperation and evaluation of methodologies not only to prevent catastrophes but also to mitigate their impacts within the humanitarian field, arguing for the

potential technologies development in tackling disaster mitigation and relief (Carrara & Guzzetti, 2013).

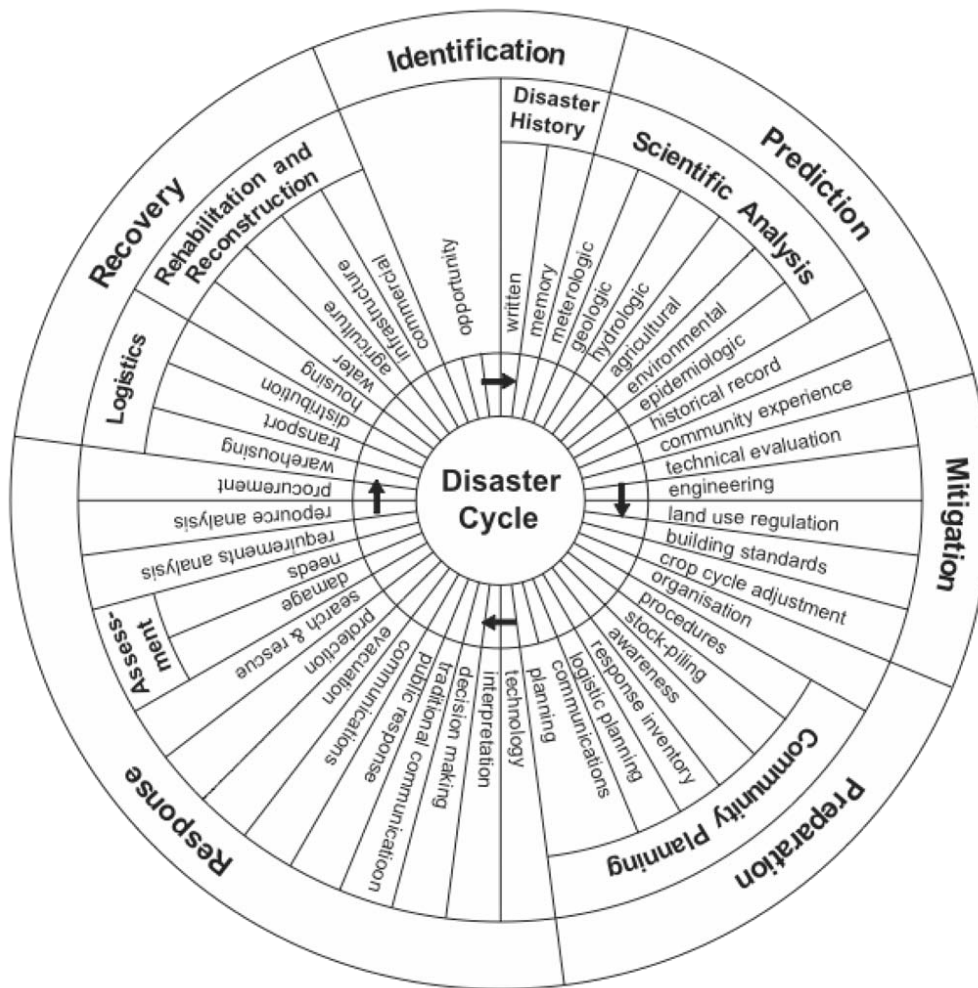
GIS based systems are efficaciously used in government-based institutions for man made and nature disaster management, as in the United States its widely used to monitor seismic damage in water distribution and road infrastructure (Werner, 2003) as well as in India for draught management and prediction (Venkateswrlu, 2004), for instance.

The process involving disaster management is composed of several methodological steps, depending on type, time frame and intensity of disaster crisis. In this particular context, strictly natural disasters will be taken into consideration for discussion purposes and only the time frame during the deployment of emergency crisis action will be highlighted. Apropos the latter, the immediate aftermath of a disaster crisis outbreak is the crucial time in which key actions and responses need to be deployed by field workers and where resources as well as information on the disaster impact are most limited (UNDAC, 2013). Consequently, GIS data on the infrastructure and further relevant information for humanitarian aid has to be very relevant and pragmatic, as demand for situational information in affected areas is very high during a crisis. "Mapped information is very important for creating a shared operational picture of a disaster situation, and for coordinating the response. Humanitarian responders may arrive with no geographical knowledge of the affected area. Effective mapping of assessments and aid delivery is needed to avoid gaps or overlaps in response efforts" (UNDAC, 2013, p.11).

Natural disasters leverage the local capabilities and resources as well as coordination with involved organizations to provide victims with immediate relief, which brings a need for community resilience. "The private sector (and community resilience) has brought to the table a range of information, capabilities, and resources that has not only filled many of the response recovery gaps (...) but has also resulted in an overall reduction in community vulnerability (in disaster response)" (Haddow et al, 2014, p.15).

The technological side of GIS brings preciseness to the humanitarian aid deployment and a system of generalized relevant large sets of information to the domain of emergency management. Hence, disaster GIS is utilized with the main objective of providing information and alerting the information addressee to further instruct on which actions to be taken during crisis management. Plus, with efficient data compatibility for uploading, real time response data can be visualized through Web GIS in fieldwork.

In applied circumstances, the use of GIS for humanitarian work has been utilized in several stages of disaster assessment cycle. For instance, remote sensing imagery has been broadly probed in landscape prediction and disaster mitigation, aiding further as source for GIS appliances such as modeling and scientific analysis of infrastructure and land use, in preparation for a natural disaster or community planning (Venkateswrlu, 2004). Geographical sourced information and analytical tools for geodata aid professionals and volunteers to create tools in which this data can be put to direct use and practice in the response phase of natural disaster, such as harvesting, modeling and sharing information after the massive earthquake in Haiti in 2010 (Zook et al, 2010) or Response Estimation System for Cyclones Under Emergency (RESCUE), a GIS application for modeling damage ratio and aid requirements in case a severe cyclone hits Bangladesh (Maniruzzaman,2010). Though GIS is still largely applied towards risk-assessment and urban planning, community-based modeling and web applications for disaster GIS have increased.



**Figure 1:** Multiphase disaster management needs in the humanitarian context represented in a cycle diagram and timeline of events. (Leafer et al, 2006, p.116).

The role of these GIS applications for disaster preparation have increased in importance for the transmission of disaster information during regular times, disaster outbreak times and recovery of what was damaged. To introduce an operational manner of community inclusion in these roles of disaster GIS, Yamamoto and researchers at the University of Electro-Communications in Tokyo developed a platform of social media GIS, targeted towards young adults within a specific region of the Tokyo prefecture, evaluating the effectiveness of its usability through a user qualitative feedback survey. (Yamamoto, 2015).

Further, this application was developed supported by the definition of scientific knowledge, which divides the latter into two different types: “local knowledge” and

“expert knowledge”. Local knowledge in this context refers to the experience-based knowledge of local residents that not often is communicated through technological or official platforms, but rather shared among small groups. Though, this knowledge can be expanded into an explicit type of knowledge, following Yamamoto’s argument, by augmenting the availability through the use of information systems combined with social media. In GIS’s case particularly, the case study for this Web GIS platform project was the earthquake frequency and mitigation in Tokyo that can feed geographical information to a user-friendly GIS platform, but also can be combined with aspatial data platforms to provide public information commons. Thus, the prototype opened a discussion for humanitarian and disaster GIS platforms to be synced with social media platforms, as both can provide public information commons, vital during disaster outbreaks (Yamamoto, 2015).

In disaster management cycles, data handling and publication can be a costly process, as relevant data for humanitarian deployment often comes in large sets with different sources and oftentimes duplicated: reliable data management and analysis requires technical insight at least at a basic degree as well as situational position or a more user-friendly application for data storage and management, where different involved people can handle the information at a low cost during crucial emergency hours. GI services hosted in a Web environment offer a lightweight, precise and broader data access: more users can analyze and visualize geodata hosted in Web GIS services without the heavy and unfavorable process of harvesting large data sets, with faster response times and up-to-date information (Kralidis, 2007). Hereafter, GIS in a Web environment presents innovation and further possibilities for aspatial data and collaborative aspects to the use of spatial data in addressing action planning for disaster relief.

#### *VGI – Volunteered Geographical Information*

The platforms where geographical data are shared have been quickly developing in the past decade, as public participation in generalized events drastically improved with the broadening of social media and access to information through the Internet. Similarly, geographical data has been positively affected by further public participation into data



generation. New added features in the Web 2.0 <sup>1</sup> such as cloud storage and smartphones contribute to the increase of user-generated data for all purposes. (Rouse; Bergeron; Harris, 2007)

Hence, the same concept also appeared regarding geographical data in the mid-2000s, first documented in the 2007 *NCGIA VGI Workshop* (Sui et al, 2012). Historically, geographical information and relevant spatial data was produced and shared between organizations and institutions, characterizing the *official* or *authoritative* sourced data (Camponovo et al, 2014). Official data sources often being governmental, military or sourced at research institutions are gathered by professionals as this data has oftentimes-restricted use. “It is widely acknowledged that maps (and all forms of geospatial data) are essential in the earliest stages of search and rescue, that evacuation planning is important, and that overhead images provide the best early source of information on damage; yet the necessary investments in resources, training, and coordination are rarely given sufficient priority either by the general public or by society’s leaders” (NRC, 2007, p.2). The advancing web based technologies in the geographical information field as well as pretty much all scientific and technological fields also made possible for low-cost entry to users without prior experience in the field to better understand and possibly engage into employing basic digital mapping skills, otherwise only done by trained geographers and cartographers (Goodchild; Glennon, 2010).

Further, the broader access to mapping tools can also be related to the lowering cost of hardware and its development; as up until the 1990s when GPS technologies started to be further applied, acquiring mapping and surveying equipment was costly. Conversely, during the last decades the cost-entry for mapping shrunk into basic hardware such as a personal computer, facilitating the bloom of VGI and crowdsourcing in geography due to the expansion of information and communications technology (ICT). “A second important benefit of Web 2.0 and disaster mapping is the ability to leverage ITs to allow individuals to report on local and specific conditions” (Zook et al, 2010, p.12).

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<sup>1</sup> *Web 2.0* is a coined term used to describe network technologies used to leverage the potential user contributions and interactions (O’Reilly, 2005).

<sup>2</sup> *Interoperability* is defined as the ability to exchange and make use of information or data, operating in conjunction with one another (Oxford, 2017) . Hence, the data interoperability in

One major advantage regarding VGI sourced data is the forefront state of the information due to the rapid production, capturing the physical space while undergoing changes. Hence, this quick data processing is especially significant in time-dependent actions, just as disaster relief. One of the terms to define the participation of volunteers from various backgrounds in producing geographical data was coined by Goodchild (2007), encompassing the production of geographical information for all purposes with *volunteered geographical information* (VGI).

Remarkably, one particularly notable case of VGI engagement, specifically for disaster relief, took part in 2010 when a massive earthquake hit Haiti: a humanitarian emergency happening in an underdeveloped country where more than 200,000 people were killed and 1.7 displaced and resources are scarce. By that time, the use of Web 2.0 and mapping already was advanced and the entry level for volunteers was relatively lower than when GI tools were only accessible for authoritative data, years prior. In Haiti's case, the conditions were considered extreme, as Haiti has always gone through social and political challenges with lacking infrastructure and spatial data. In response to this need, the volunteer efforts used web-based tools with nonprofessional data contributors and spatial data made freely available on Google. "Information about opportunities to contribute spread quickly through a variety of online outlets, including blogs, emails, tweets, and status updates" (Zook et al, 2010, p.16).

The volunteers provided data through mapping platforms such as OpenStreetMap and *Usahidi*, combining their efforts into sharing real-time data about where to find resources for basic needs, reports about medical emergencies and hazardous areas. Also, the Haitian community was included in filtering content from the social media platforms that could be added to the map (Haddow et al, 2014).

Following, the motivation for VGI data production is a large part of the reason why geographic public amateur data is produced in contrast with authoritative data. Hence, volunteers in geographical information often seek to help other people as well as gain insight with action within scientific data production and have their contributions perceived as educational, the often inaccessibility and the virtual null actual and time cost of geographical data production when using open source tools (Zook et al, 2010). VGI can be seen as one example of citizen inclusion in science, as people contribute with

data management and production for free. “Similarly, the combination or conflation of several independent maps of the same phenomenon can often be expected to provide a better estimate of the phenomenon than can individual maps” (Goodchild et al, 2007, p.253).

Consequently, various examples of VGI and volunteered mapping towards underdeveloped or crisis zones are seen in the Internet today, mostly led by OpenStreetMap, which is a global street map dataset with absolutely no proprietary copyright restrictions, with user-generated maps (Rouse et al, 2006). The user-generated spatial data aggregated with *aspatial* information used in WebGIS applications facilitated the perpetuations of projects to readdress the meaning of community participation whether in disaster management, in policy planning, or simply mapping as data gathering. Researchers have taken good advantage of this facilitation by integrating data into GIS access for knowledge distortion, by sampling data in South African communities and combining audio and photographic descriptions of remote community areas to GIS online maps as mentioned by Harris and Weiner in their early PGIS field work (Rouse et al, 2006). Arguably, the integration of information and GIS for web applications can be powerful and useful in a sense of a collaborative web-mapping platform, corroborating empowerment and usability arguments.

#### *Social media and aspatial data collaboration in GIS*

Social media interaction proposes a low-level entry interaction in different sorts of application where it is implemented. When the aim is to provide information and data within time sensitive issues, social media event broadcasting has increased its coverage and effect as its user has grown in the last few years: “Research shows the majority of Twitter content come from traditional mass media during disasters, a practice termed “information broadcasting and brokerage” (Beaumont, 2011, p.156).

Not only collaboration can be extended to citizens who are familiar with social media information dissemination only, but also the extended outreach to this same target group of whichever event where there is a security threat. Hence, the interpretation of straightforward broadcasted information has not only a different and larger target

group, but also a more effective implication of information dissemination within minutes, vital when disasters take place. “The Japanese are major users of the Internet and social media and the country has sophisticated disaster-warning systems. A clear lesson of the 2011 earthquake and tsunami was the “importance of using all possible channels and technologies, from the highest tech to the lowest, (...) to reach the most vulnerable populations with critical information when disaster strikes.” (Appleby in Haddow, 2014, p.158). Some GIS applications can be challenging to be interpreted by the general public, the majority of citizens affected by natural disasters. When applications are developed with a high-entry user level and technical aspects for the information channel, the target group narrows and outreach of relevant humanitarian/disaster data narrows alongside. Thus, social media can be presented as a relevant tool to complement the GIS visualization of geographical data in disaster outbreaks.

An example from how social media can work as a complement to GIS and disaster response technologies comes from Australia, after flood peaks in Queensland and shared information over Twitter hash tags, where the organizations involved also used social media to share coordinate responses. “The growing use of social media occurred organically, as it became recognized as the easiest and fastest way to get information out to the community” (Haddow, 2014, p.161).

#### *Case study: Valparaíso, Chile*

Located in the central coastal area of Chile, Valparaíso is one of the most populated regions of its country, comprising a metropolitan area of 16.369,1 km<sup>2</sup> with 284.630 inhabitants in its capital of the same name. Valparaíso is located relatively close to Santiago, in central Chile. As the rest of the country, the region is prone to earthquakes due to its position settled close to the Atacama trench, the gap between two large tectonic plates.



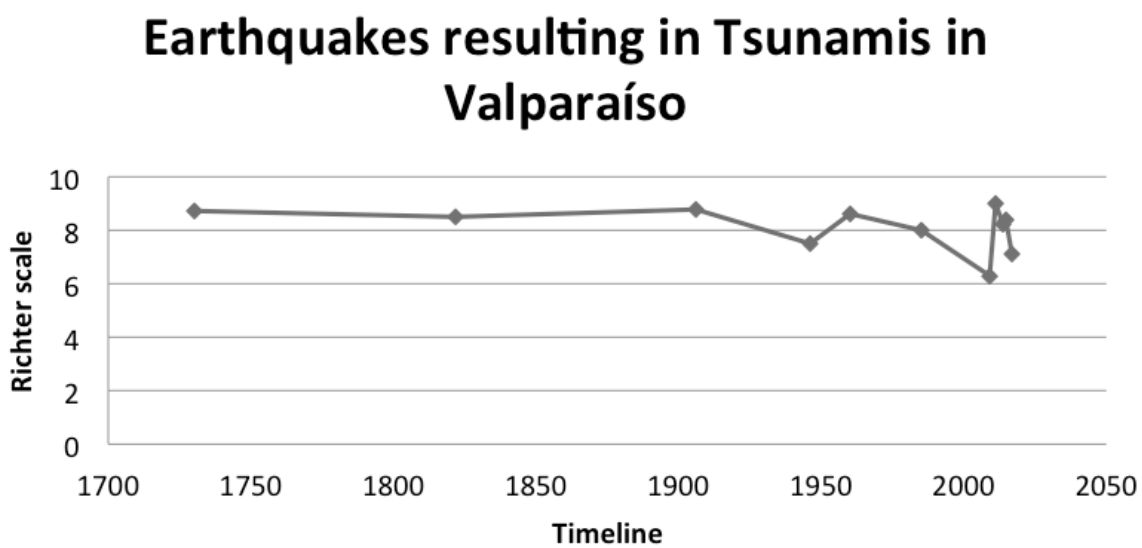


**Figure 2:** Satellite imagery from Valparaíso, view of the downtown and the port in the center of the image  
(Google Maps in QGIS, 2017)



**Figure 3:** Satellite imagery from Valparaíso boundaries (Google Maps in QGIS, 2017)

The town of Valparaíso itself is found between a mountain range going up to 2000m and a coastal line with a large harbor. Further, in the intermediates of the most densely populated area of the city and farther into the country, an intermediate depression and plain area without much development can be found, which comprise dry vegetation types. Due to its unfortunate timeline of emergency incidents, the city of Valparaíso, alongside with other risk areas throughout Chile are often addressed when concerning geographical data for disaster management, mitigation or relief. Historically, the region of Valparaíso has endured several violent earthquakes, wild fires and tsunamis.



**Figure 4:** Highlighted earthquakes in Valparaíso that resulted in Tsunamis within the same region compiled by Instituto Nacional de Estadísticas (INE, 2017).

In figure 2 above, only the most severe earthquakes with strong aftermath effects in Valparaíso (including tsunami alerts and general infrastructure loss) are included. Thus, there were several other earthquakes of smaller scale with their starting point close to Valparaíso, which are not depicted in the graph. Nonetheless, its visible the frequency of severe earthquakes in the area and the need for mitigation and responsiveness regarding the latter.

Accordingly, the responsiveness of the competent authorities, facing that Chile is geographically-speaking a risk zone of several different potential natural disasters, is centralized within the government counts with a national civil protection system

(*Sistema Nacional de Protección Civil*, in Spanish). The latter is responsible for disaster prevention, mitigation, and vulnerability assessment and whenever in an emergency; all its resources available are reallocated to the purpose of disaster relief. Though, the institutional capacities in Chile are stiff and hierarchical, providing little integration of efforts towards a more efficient disaster response management policy. Also lacking is the transparency of public management and community interaction, whereas a precise risk analysis of social vulnerability towards natural disasters is missing.

GIS fits as a potentially solution tool not only to re-establish the interoperability of humanitarian and disaster relief among institutions, but also towards urban zoning and urban emergency plans (Coddou, 2006). As shown in the disaster cycle, several steps of mitigation, planning or even community involvement can be further backed by data and scientific analysis – which does not necessarily mean a high user knowledge in geographical information, as it will be further discussed.

Including the general public into such information sharing can be done by lowering the entry level bar of such applications, which often require previous experience in visualizing geographical data in online applications or softwares.



## Methodology

Using knowledge acquired during the two years of this master's program, this paper intends to explore real life appliance of new GIS trends. Thus, focusing on the interoperability<sup>2</sup> and methodology of data management for this particular context, this WebGIS prototype highlights the importance of citizen and public involvement with scientific tools, developed to implement a large scale benefit in disaster situations. Firstly, it was vital to delineate the relevance of data types throughout the process of humanitarian relief, to delimitate the application's size and weight.

### *Target user group and application purpose*

Target users are mostly the general public, to include them in "data production and harvesting" through adding *aspatial* data and constant status update to the disaster-oriented map. Though, the potential user group could very well be expanded depending on functionality and need for field work in emergency deployment in Valparaíso as well as if urban policy makers and planners find useful to incorporate further information from the public as feedback and background for mitigation and planning in a future case. Further, the objective of this application leans towards a collaborative public engagement, which does not exclude any other potential user group rather than the general citizen public in the Valparaíso region, such as volunteered helpers, field workers or observers.

Hence, when observing the employment of VGI in natural disaster and emergency relief, collaborators were found from several locations, also being able to deliver remote help. On that account, the final purpose of the WebGIS application prototype discussed throughout this paper would present its flexibility of data interoperability as the resilience of its hindmost appliance: ranging from informing the general public and

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<sup>2</sup> *Interoperability* is defined as the ability to exchange and make use of information or data, operating in conjunction with one another (Oxford, 2017) . Hence, the data interoperability in this thesis context echoes the exchange of multi-sourced data between different platforms. Retrieved from <https://en.oxforddictionaries.com/definition/interoperability> (Last accessed on 15.04.17)



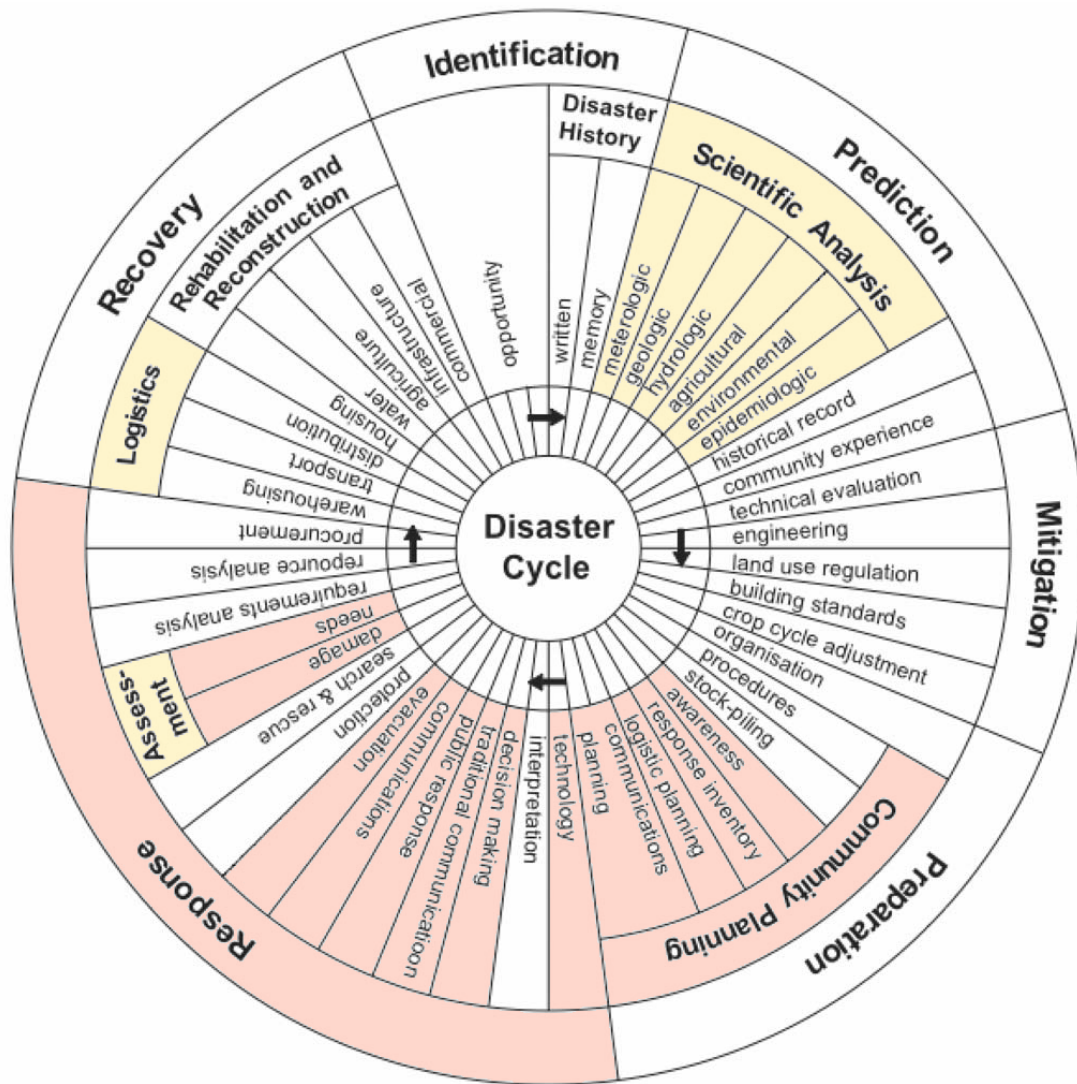
allowing the latter to update and share relevant information regarding the disaster, to being used as information platform for decision making in emergency relief.

Also, relevant data provided in text format that can be updated in real time are also a very useful add-on to informative thematic maps.

#### *Relevant data used*

During crisis management, presentable data is selected to carry out the process of defining prioritized action during emergency relief, shaping up the priority in data display for GIS applications designed to be used in disaster situations. To better understand where the data harvested and shared through GIS platforms can fit into an emergency plan of action, a disaster cycle is observed.

Spatial data used in specific for disaster management and emergency relief may be presented with several characteristics, oftentimes depending on the source where this data was obtained. Further, not only presenting physical structures but also giving it attributes that can be considered as aspatial data e.g., characteristics, age, comments, photographs, and structure elements just to name a few aspects (Leafer et al, 2006, p.117). Hence, this distinction remains relevant specifically in this context due to the incorporated element of public interaction on the Web GIS platform suggested in this paper, whereas updated information in the database is not necessarily spatial data per se, but aids the assessment of the spatial visualization.



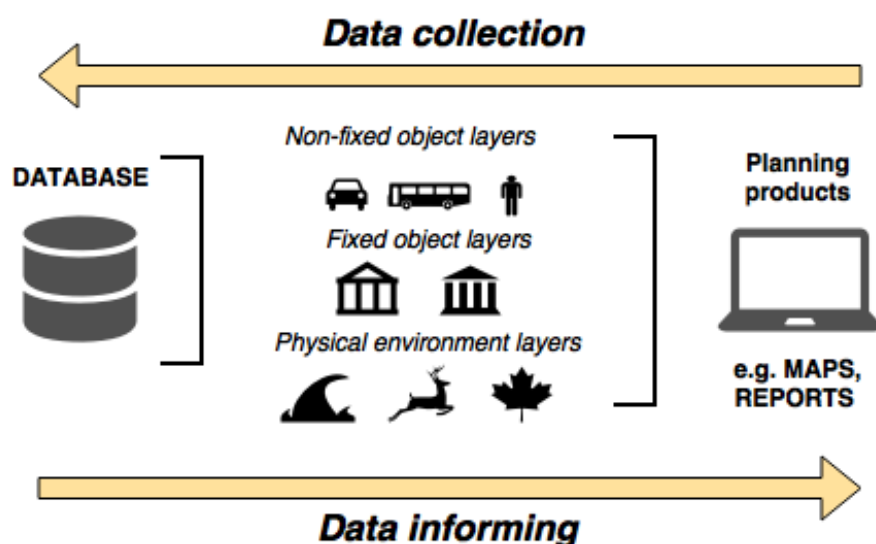
**Figure 5:** Multiphase disaster management needs in the humanitarian context, with highlighted fields in regards to the relevancy in this project's context (Leafer et al, 2006).

The figure 3 above shows the timeline of events during the action management in disaster outbreaks or humanitarian emergencies. Hence, the highlighted processes in light orange relate to the GIS deployment along the disaster cycle as a tool to facilitate the actions there mentioned, e.g. the scientific analysis, where the representation of physical characteristics are used for further analysis into conditions for disaster prediction. Further, the non-static and static objects that characterize a landscape can also be mapped and analyzed through GIS, thus the *logistics* and *assessment* periods are also highlighted into being part of GIS implementation.

Naturally, other steps of the disaster cycle can also be facilitated with the use of GIS (such as technical evaluation and land use regulation, for instance), though the latter are not directly related to the humanitarian context in which GIS plays a role described in this project. The highlighted actions in salmon color are directly related to this project's aim and research questions, where the implementation of this Web GIS application prototype relates forthwith. Regarding community planning, the participatory aspect of this application has a precise connection with *awareness* and *communication planning* in the graph, according to the main goal and argument for collaborative GIS.

Disaster response definitely is the cycle period to which this application is designed for, as it prioritizes aspects of data gathering and data visualization for guidance after the disaster outbreak takes place. Then, the further salmon colored fields within *Response* correlate to this project's backbone argument, target users and utility.

Based on the data cycle diagram for humanitarian agent based models, the diagram above depicts the data flow in representing especially humanitarian purposed platforms and the types of data that flow throughout. Further, it differentiates the layers of relevant data used in the humanitarian and disaster context that prioritize data that can be useful in such context.



**Figure 6:** Diagram based on *Data Cycle for Humanitarian Agent Based Models* by Cooks & Wise, 2013.

Hence, in the specific case of humanitarian agent based models and platforms created for disaster GIS, the methodology and implementation technical aspects rely on rapid information update and differentiation between types of information, as depicted in the Figure 6 above. Further, it can also have different databases in its system design, as in relational databases, with social and spatial information stored and catalogued separately. In this case though, the more complex system design of such applications have implications in loading times and narrower usability options, as having more ramifications in its structure for different sorts of data being aspatial or spatial.

“With existing and new data constantly being added, a baseline system must provide efficient data storage because of the need to obtain real-time data while a disaster is occurring” (Leafer et al, 2006, p.118). Keeping in mind the necessity of real-time updates to corroborate the usability of this Web GIS application, one of the most important aspects thought through the methodology of its system design and process timeframe was the focus on lightweight of the latter. Given the importance of speed and clarity in this particular crisis situation, the data harvesting process and data format were fundamental steps to be considered. Within the map, the layers from different sources were sourced complementing each other regarding how informative during a humanitarian crisis this particular data would be. Therefore, the governmental data layers are not meant to display redundant or repetitive spatial data that is already contained in the base map, rather to complement and clarify what could be missing.

Furthermore, the concept of thematic maps is also applied in this context, as this map is produced with geovisualization aspects proper for this end goal of humanitarian and disaster information. Thus, typical visualization symbols and characters were taken into account to describe relevant spatial reference and data in a map that makes sense within the context where it is applied.

In this very context, several alternatives considered, balancing clear geographical information and the theme of this web GIS application. In order to select and justify the given choices of points of interest displayed in this map, cartographic data visualization mentioned in humanitarian standards (Haddow et al, 2014) were prioritized based on the literature. Though the most common choice for a humanitarian base map would

perhaps be the HOT OSM<sup>3</sup>, this base map proved to be slightly too filled with unnecessary information, as it's freely editable online. Hence, it mismatched the purpose of cleanliness to deliver crucial information with this application as this prototype is sought to show relevant and clean information, without much information pollution in the screen. The latter takes into account the loading times and the collaborating aspect.

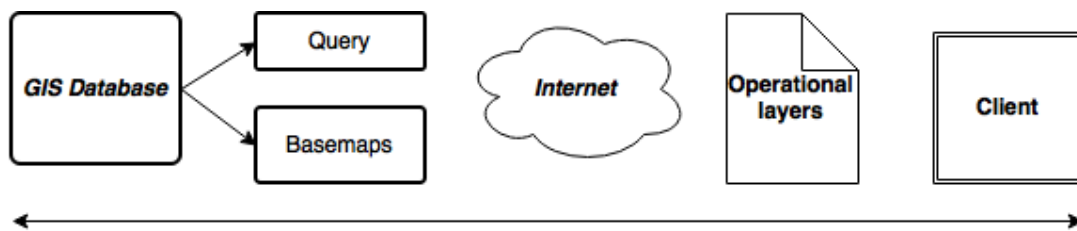
Even though the HOT OSM is one of the most disseminated VGI collaborative base maps, there are alternatives also using the VGI aspect and highlighting other characteristics relevant for the humanitarian topic – leaning towards the geovisualization research topic on user experience of geographical information display, applications and map design. Geovisualization remains a relevant subject to be taken into account, especially when only the very relevant time-sensitive data is to be displayed to deliver a better user-experience in the humanitarian context.

Hence, this prototype opted for researching alternatives towards the OSM, landing into Stamen – which is an open source-mapping provider, involved with research for humanitarian purposes taking into account natural disaster and geographical characteristics. Further, the base map used in this prototype is ranging from two options: first, a base map developed and initially designed for a Web GIS application displaying information regarding the earthquake that took place in April 2015 in Kathmandu, Nepal by Stamen and research partners. Secondly, the alternative option for the base map displayed is also provided by Stamen, though without humanitarian POI – highlighting only the terrain differences, as it is relevant to Valparaíso's geographical landscape and city zones.

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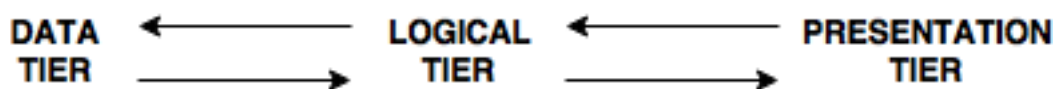
<sup>3</sup> HOT OSM refers to the Humanitarian OpenStreetMap team, which compiled and developed a base map specifically for humanitarian purposes, highlighting layers and physical features of the map that can aid humanitarian help deployment or guidance in disaster outbreaks.

In the infrastructure of a WebGIS platform designated to disaster aid, the technical structure remains similar to a WebGIS application towards a general use, though with specifics that are particular and important in disaster management.



**Figure 7:** Best practice for workload partitioning in thin and thick client GIS architecture (Fu & Sun, 2011, p.41).

According to Fu and Sun, the current best practice to be implemented in GI system infrastructures and design involve the base maps being loaded and done by the server, whereas the layers (called operational layers in the diagram) are usually rendered by the browser. To facilitate the use and loading of such applications, it is recommended that the heavier functions rely on the server and the lighter easier functions be performed by the browser instead (Fu & Sun, 2001).



**Figure 8:** logical architecture and workflow of basic WebGIS applications with three separate tiers (Fu & Sun, 2011, p.33).

## Implementation

In this chapter, the processes involved to develop the application are described in detail. Also, the reasoning for choices of system design, platforms used and implementation are justified with provided relevant information.

As the discourse of accessible geographic data mains of production continues to grow, several new platforms emerge. In general, most of them seek to aid recurring issues when geographic and spatial data harvesting and displaying: problems with large amounts of heavy data to be displayed in slower Internet connection environments, expensive and proprietary spatial data, services, platforms as well as software that require academic and scientific knowledge in order to be effectively used. Accordingly to this thesis background and goals, alternatives to include further geographic data production and harvesting were sought. Therefore, the backend section of the proposed WebGIS application follows the usability and disaster response data needs<sup>4</sup>. Further, the implementation of this system's design supersedes the premise of its end goal: displaying straightforward helpful information during humanitarian crises, easily accessible to a varied range of users. This premise allowed for additional focus on web and mobile usability, which lead to specific choices throughout the implementation.

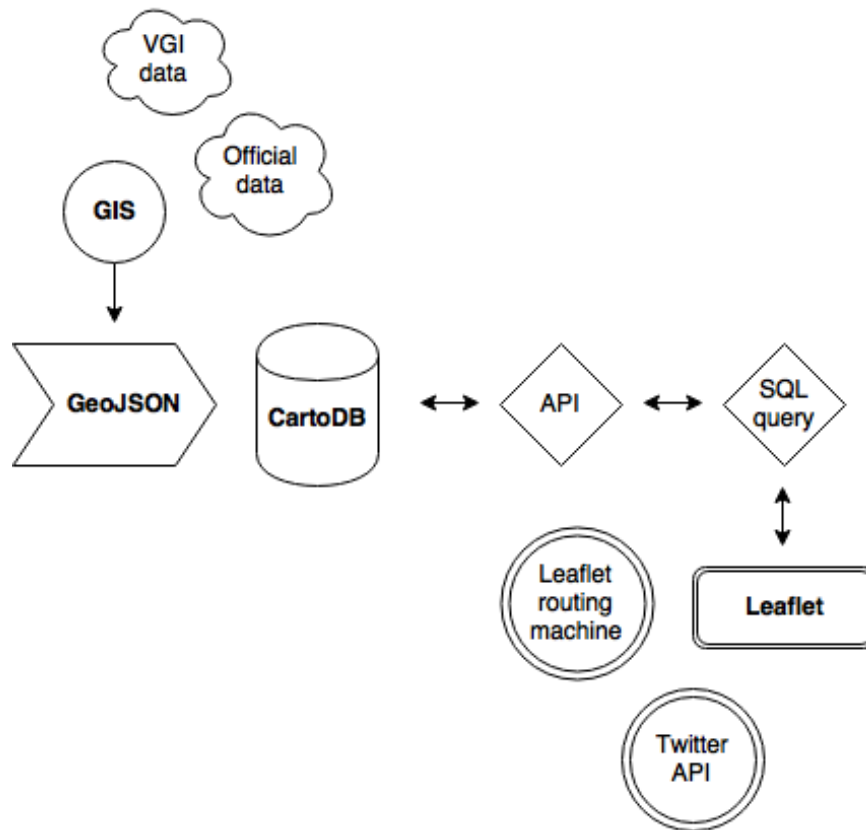
The data sourced displayed as relevant layer data in this application, was provided by different online sources. Ranging from data provided by collaborative and volunteered and from official sourced in Chile, the first mentioned was sourced through Web GIS collaborative platforms such as HOT OpenStreetMap, retrieved through QGIS. Though, most layer data displayed in the front end of this application was sourced at the The National Catalogue of Geospatial Information in Chile<sup>5</sup>, also its geoportal with interactive visualization of specific layers and the Library of the National Congress in Chile<sup>6</sup>.

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<sup>4</sup> For further description on data needs within the humanitarian and disaster crisis context: See Chapter 2.

<sup>5</sup> Infraestructura de Datos Geoespaciales IDE Chile located in the Ministry of National Data: <http://www.geoportal.cl/geoportal/catalog/main/home.page> (Last visited 04.06.2017)

<sup>6</sup> Biblioteca del Congreso Nacional de Chile: [http://www.bcn.cl/siit/mapas\\_vectoriales/index.html](http://www.bcn.cl/siit/mapas_vectoriales/index.html) (Last visited 04.06.2017)



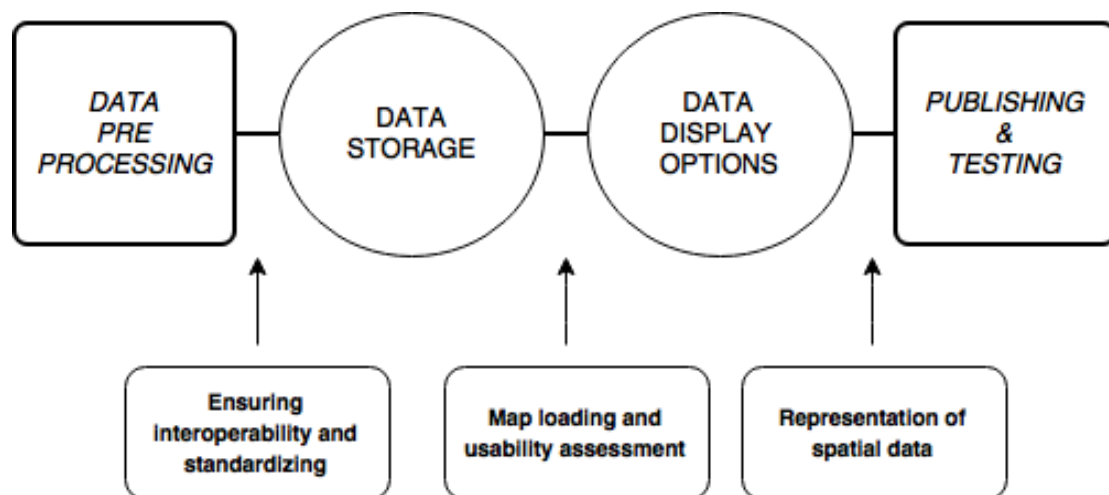
**Figure 9:** System design of the Web GIS application prototype for disaster response in Valparaíso, Chile. Several data sources were used as well as add-on and further Leaflet libraries, additional to the basic Web GIS system architecture as displayed above, with specific platforms used in this case.

### *Data Backend*

In order to display informative data in a dynamic way, data storage had to be carefully taken into account, considering loading speed for the end user (Leafer et al, 2006). In addition, data interoperability was another aspect to be considered, as this application aims to display data provided by the public, VGI sourced information as well as spatial data retrieved from authoritative sources. Oftentimes, these data does not necessarily follow a metadata standard or use the same reference system, which calls for a data preprocessing as the first step of this map implementation.



Firstly, relevant spatial data was retrieved from the governmental institutions and research centers in Chile (Please refer to page 22 footnotes). After researching the availability of this data, the latter was filtered according to relevance, as the ultimate goal is to inform but not to pollute the map with unnecessary extra information. Following, vector layers were selected in order to represent authoritative data in the Web GIS application, retrieved from official sources in Chile rather than from volunteered sourced information. However, the vector data was further edited and projected accordingly on QGIS<sup>7</sup> – chosen as GI software due to its functionality and, mainly, due to its free availability as an open source platform and plugin availability to connect with Carto (later described in this chapter).



**Figure 10:** Diagram representing the thought process behind this WebGIS application implementation tasks.

After vector and point data to be used is set to the correct reference system, all files are converted to GeoJSON<sup>8</sup> format, due to its compatibility with the storage platform as well as being a lightweight format, allowing more files to be stored and displayed in the application. Further, GeoJSON allows polygon editing in the backend coding for the map

<sup>7</sup> QGIS is a free and open source software for geographic information systems licensed under the GNU General Public License by the Open Source Geospatial Foundation (OSGeo) – Las Palmas 2.18 version (Retrieved at <http://www.qgis.org/en/site/> - Last accessed on 16.04.17)

<sup>8</sup> GeoJSON is a data format specifically designed for encoding geographic data structures and features along with non-spatial attributes based on JavaScript language. (<http://geojson.org>)

display. Going along with the main objective of this prototype, the data size was one of the major aspects to be carefully considered, as it aims for better usability, fast loading and the possibility of collaboration and expanded data storage. Concluding, the data pre-processing part is over, where standardizing and organizing the datasets are prior to choosing where they would be stored.

### *Carto and Interoperability*

For the data storage, the data size and extension type were the main aspects to be considered. In this case, several approaches were evaluated, first beginning with a standard database that would be able to comprise geographical data and allow for vector files with their specific geometry. As mentioned, the first of a couple of options was creating a database using a SQL database platform with a geographical extension, being PostgreSQL with PostGIS enabled. In this case, the software used would function as the frontend of the main database for this application, where a server would have to connect both ends.

As this project proposes to evaluate current solutions for displaying essential geographical data in a fast and convenient manner, other solutions were approached. Currently, there has been a bloom of open-source and small companies providing map services online, even to inexperienced geographers, curious users or volunteers. This approach allows users to elaborate rich maps using a simple frontend interface that does not require programming or GIS knowledge.

Naturally, in order to produce a map with more elaborated data, this data has to be pre-processed by a GIS professional or user with longer experience in such matters. Further, during the researching for alternatives, Carto<sup>9</sup> was considered ideal for this prototype testing for several reasons. First, this online mapping service not only functions as a front-end platform to produce maps, but it also offers a database service within Carto,

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<sup>9</sup> CARTO is an online service created in offering free and paid mapping and data storage services for geographical data visualization and GPS tracking among other GI services. (<https://carto.com/solutions/non-profits/>, Last accessed 27.05.2017)

where data from several types of extensions can be added as tables without conflict of interoperability. Second, this service offers a very straightforward data storage interface, where users can simply drag and drop files and visualize them as layers when creating a map, also setting privacy options. Its compatibility advantage ranges from the data types to several base maps, becoming even more customizable by mid-range and advanced users depending on the visualization goal of given created map.

Its services can be connected through API keys provided to registered users, which access limitations follow the user's account type. For this paper, a student account was used in partnership with GitHub, where basic services and limited storage is freely available to registered students. Given this information, the free basic services provided on Carto were definitely enough to host a fully functional and optimal inclusive web GIS application. When considering the implementation of this application, the user-friendliness of Carto, even to add data by low-entry potential users, presented a very positive aspect. Having collected all the relevant data from the different sources mentioned in chapter two as the seven added layers, they were all uploaded to Carto, which functioned as a database storing GeoJSON files.

The datasets are set as public data, which can be assessed as tables within the Carto platform. For visualization purposes, a map was created to see whether the GeoJSON layers would show up as previously edited on QGIS. The *map loading and usability assessment* was a vital role into deciding which and how the layers would be displayed within the final map. The importance of showing relevant information for the disaster response purposes was the main thought process behind deciding how the layers would be displayed, as well as the base map used on Leaflet and the test map on Carto. Refer to source code in Appendix.

As Carto data storage worked as the database for the application, the following concerns were the visualization display and the loading time, as well as the relevant functionality of the application.

Further, the usability and collaborative aspect were carefully considered, as they were the backbone of this prototype from the very beginning. In order to be truly

collaborative and interactive in the geographical point of view, there should be alternatives to load geographical data into this application. Even though the application in state-of-art does show layers harvested from different providers, including VGI sources, the possibility of uploading further geographical data was evaluated. Thus, the interoperability in Carto played a large role to make the latter possible. Hence, in the backend, a query was provided within a loop to reload data uploaded in the Carto database and be automatically loaded onto the Leaflet frontend with assigned styling without repetition.

```
$.ajax({
    url:
    "https://camilafraiz.carto.com/api/v2/sql?q=select pg_class.relname
    from pg_class, pg_roles, pg_namespace where pg_roles.oid =
    pg_class.relowner and pg_roles.rolname = current_user and
    pg_namespace.oid = pg_class.relnamespace and pg_class.relkind =
    'r'&api_key=202657682f20e069492d0d8cf31c837dce41d544"
    }).done(function(data) {

        for (var row in data['rows']) {
            layer = data['rows'][row]["relname"];

            console.log(layer)

            url =
            "https://camilafraiz.carto.com/api/v2/sql?format=GeoJSON&q=SELECT *
            FROM " + layer + "&api_key=202657682f20e069492d0d8cf31c837dce41d544"

            $.ajax({
                url: url,
                async: false
            })
            .done(function(layerdata) {

                console.log(layerdata)
```

Text: Code block containing the SQL query loop, which functions to load the GeoJSON data uploaded on  
Carto onto the frontend

As mentioned, for the layer customization, a simple condition was added to the code as well as with a styling applying picked colors to the marker assigned on Leaflet as an interactive button. The layer's metadata stored in Carto was used to reference to each layer in the code and assign respective colors to each one individually, as most data is points of interest. With the public upload functionality, the style had to be defined for potential new layers as well, so they would remain differentiated from existing ones. Hence, random colors are assigned to each new layer added to the database on Carto through a loop condition on the code. (Code block below) Further, the latter optimizes potential collaboration and interoperability of data added by different sources to use this application as a VGI platform.

```
function getColor(fclass, featuretype) {  
var letters = '0123456789ABCDEF';  
    var color = '#';  
    for (var i = 0; i < 6; i++) {  
        color += letters[Math.floor(Math.random()* 16)];  
    }  
  
    return color;  
}
```

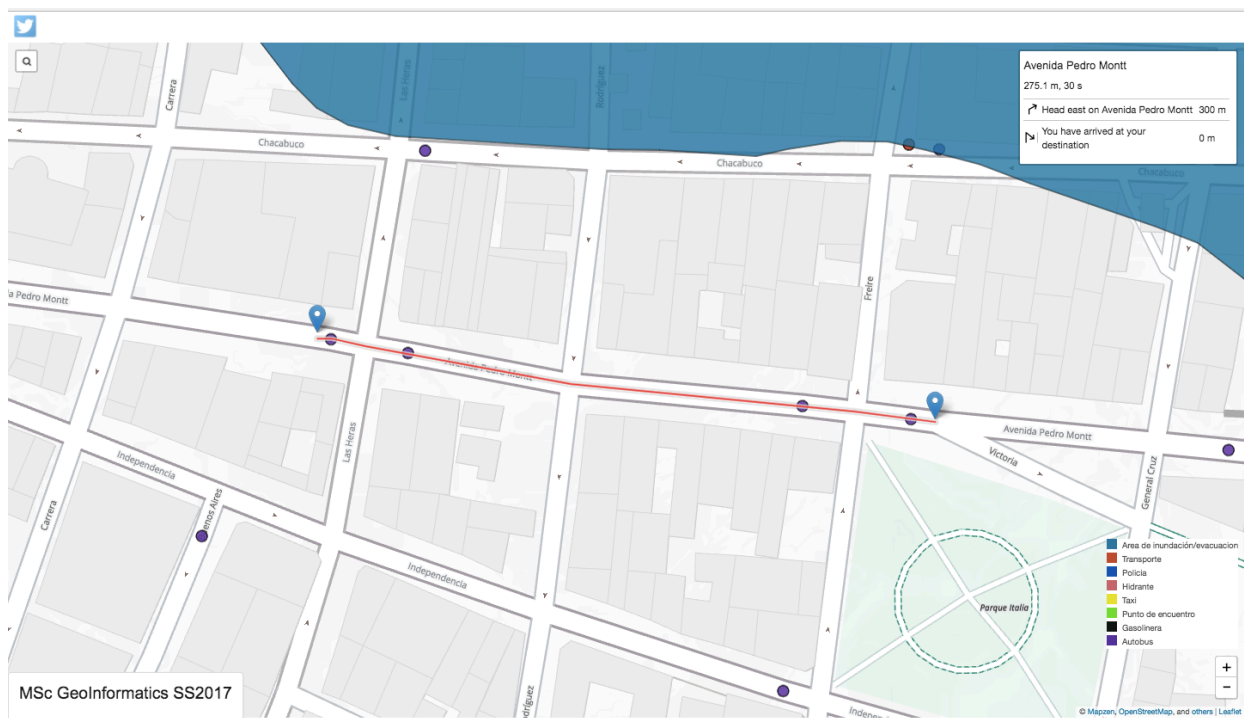
Text: Code block containing the function that assigns random colors to new layer data added on Carto, to be displayed on Leaflet. The layer data is represented by the layer name assigned on Carto, *fclass*.

### *Leaflet and the WebGIS application frontend*

Through the Leaflet additional libraries, it was possible to add the functionality of routing, working very similarly to the GoogleMaps route to find way between two points in a map. As this particular routing add-on did not have information for the public transport in Valparaíso, this aspect was left aside and sought with pointing out relevant stations and public transport access through the layers shown in the map. Nonetheless,

the routing works for cars and taxis, offering directions and the distance between the geolocated point and the desired destination.

The POI selected from the layer map opens a pop up window with the options of selecting that specific point of interest as destination or origin of route, as it becomes the first and last way point used by the coding on Leaflet routing<sup>10</sup>. Instead of giving coordinates for Leaflet to create origin and destination points, an extra function is used to substitute the *null* coordinates by new ones, characterized by the 0 and 1 number giving out the order of selection points. Also, it is possible to select further points of interest and add them to the route in a very straight-forward and user-friendly manner: the user only needs to click on the map and add the point as destination.



**Figure 11:** Image showing a simple route calculated by the Leaflet routing using POI added in the map as GeoJSON.

<sup>10</sup> Leaflet routing machine is an additional JavaScript library compatible with Leaflet mapping platforms to generate routing within a map, using coordinates as waypoints.

```

control = L.Routing.control({
    waypoints: [
        null],
    routeWhileDragging: true
}).addTo(map);

function createButton(label, container) {
    var btn = L.DomUtil.create('button', '', container);
    btn.setAttribute('type', 'button');
    btn.innerHTML = label;
    return btn;
}

map.on('click', function(e) {
    var container = L.DomUtil.create('div'),
        startBtn = createButton('Start from this
location', container),
        destBtn = createButton('Go to this location',
container);

    L.popup()
        .setContent(container)
        .setLatLng(e.latlng)
        .openOn(map);

    L.DomEvent.on(startBtn, 'click', function() {
        control.spliceWaypoints(0, 1, e.latlng);
        map.closePopup();
    });

    L.DomEvent.on(destBtn, 'click', function() {
control.spliceWaypoints(control.getWaypoints().length - 1, 1,
e.latlng);
        map.closePopup();
    });
});

```

Text: Code block containing the function for routing control on Leaflet, adding origin and destination buttons to the info window of the POI selected on the map by the user. Also, the waypoints are substituted by points set by the user when clicking on the map using the function *control.spliceWaypoints*

Further, customization of the map was implemented to facilitate the visualization of crucial aspects for disaster response. The base map was carefully selected by its use of highlights to difference in slope of the higher areas and the flatter areas within the busiest area of town, the downtown center and the boardwalk. The slope difference is an important aspect to highlight specifically in the case of Valparaíso, as the flood areas marked on the map with data provided by the authorities are naturally the flat downtown areas, where transportation is also highlighted – as option of escape routes.

Also, a layer displayed in the prototype in green point data – provided by the Chilean authorities in their geoportal – is safe meeting points in case of tsunamis, which are not only concentrated in the flat downtown area of the city.

### *Public Updates*

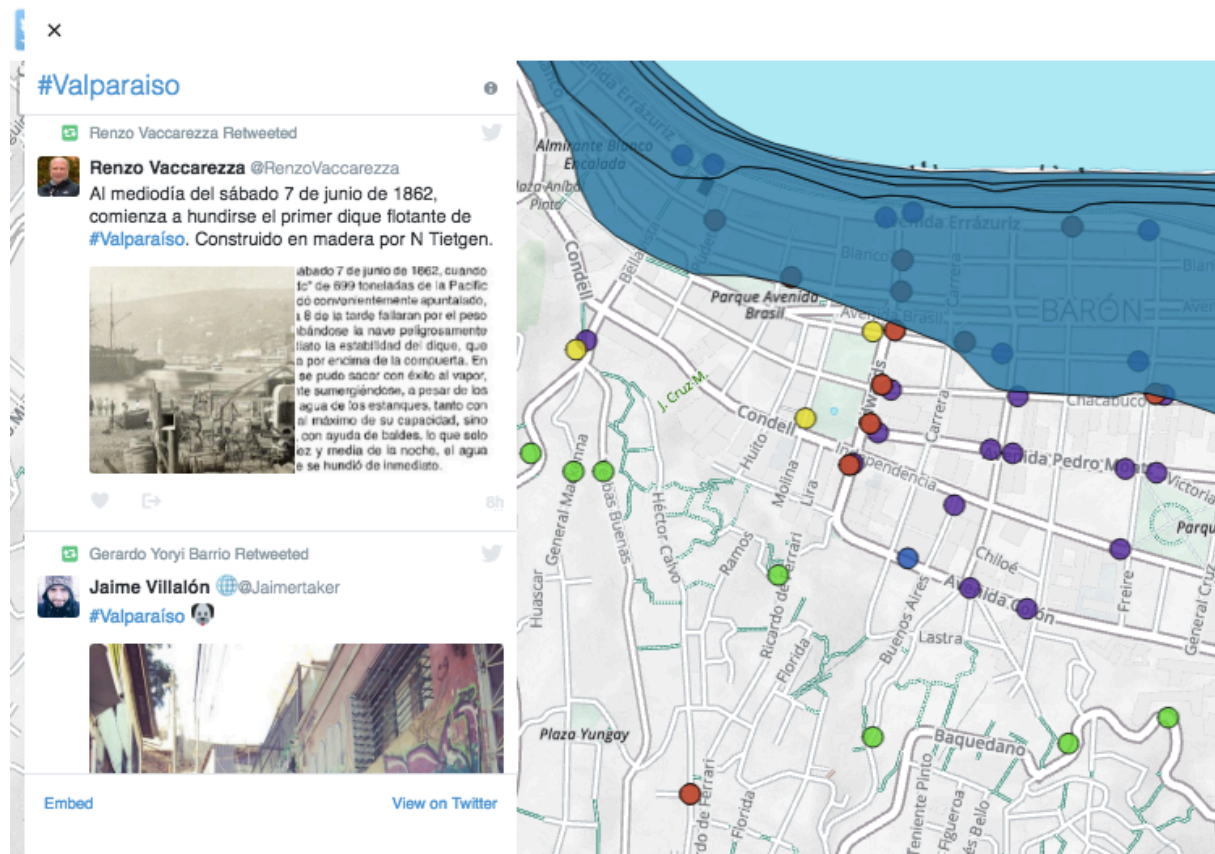
The interaction with social media was mirrored in current explorations of the VGI collaboration aspect in GIS. As implemented in examples aforementioned in Chapter 1, adding real-time information feed with aspatial data can complement and fill the information gap within the first hours of a disaster outbreak and thus, help field workers and citizens located within emergency areas (Haddow, 2014).

Hence, this application offers two collaboration possibilities: one targeted to a user-group that has at least an entry-level knowledge of handling geographical information and a very low entry-level user interaction possibility via Twitter<sup>11</sup>. In this prototype, a snippet of code using the writer's API key on Twitter was attached to a retractable column on the Web GIS final visualization. Further, it currently offers filters for tweets to be displayed in the application using hash tags and Chilean time zone.

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<sup>11</sup> Twitter is a social media platform characterized by the information sharing through short messages of 140 characters each, oftentimes accompanied with media formats and hashtags to be categorized within topics of importance within the Twitter network of each country.





**Figure 12:** Image zooming in the left expandable column of the Web GIS application with the Twitter function: tweets with the chosen hash tag are displayed and can be embedded and shared through the map page

The current hash tag – also known as trending topic when its use is extensive and show on Twitter’s homepage – used to filter showing tweets is #Valparaíso, observed to be used by authorities and citizens when uploading information and media, such as pictures and videos, when emergency or harsh weather takes place. Therefore, every tweet posted with the aforementioned hash tag can be shown in the prototype, fact that opens the discussion for further filter possibilities to have disaster focused content only.

## **Discussion**

Throughout the discussion chapter, relevant aspects of the research will be highlighted in order to favor the discussion of further development possibilities and justifications of implementation choices, driven by the research questions' scope and progress evaluation.

### *Evaluation*

The research and development of a Web GIS application for disaster response, shines light on the discrepancies of implementation of such tools in a field extensively documented theory-wise. The practical aspect of a hands-on employment functioned as a clear-cut review and understanding of the literature review, provided by other researchers in the humanitarian action and VGI field: the challenges of interoperability, not only regarding data, but also humanitarian tasks are more apparent and fathomable. Thus, the challenges of incorporating collaborative aspects to Web GIS remain to be further investigated with proposed elucidation in this paper and application prototype.

Moreover, insights gained from the literature review played an important role into the frontend development and learning process of Web GIS implementation, as it was focused in disaster outbreaks altogether. The relevancy of new angles to consider when implementing a GIS application specific to humanitarian aid and usage during an emergency, brought to light aspects that are oftentimes neglected when developing a regular authoritative geoportal – straightforwardness, time sensitivity and usability, particularly taken in consideration apart from the technical aspects of data interoperability.

Customarily, a survey would provide more understanding of the usability characteristics, positive or negatively implemented. Due to time constraints, a qualitative analysis was not carried out, which resulted the comparative literature review focus of this paper. Thus, comparatively with previous prototypes and studies, the emergence of user-inclusive alternatives to be combined with GIS defines a refreshing perspective of

mapping application and their usage expansion in the near future – accompanying the development and inclusion of the Web 2.0 and social media throughout the globe. Following the trend, the emanation of open-source platforms and volunteered geographical information platforms collaborate for implementing feasible Web GIS projects in development areas. Throughout the development of this prototype, facing the backend challenges of data storage and display, one can hint of the complexity humanitarian actors have to take into account when dealing with GIS technologies to be applied in field work.

#### *Level of user for contribution and relevance of public participation*

Collaborative knowledge is a core aspect of the discussion regarding this Web GIS application prototype. In order to remain inclusive, the simplicity must be a characteristic to bear in mind when developing a mapping platform that encloses several types of potential users.

The closer observation into user contribution leads to a potential research topic of Web GIS implementation – and the possibilities of explaining the feasible reason for GIS not be largely implemented in humanitarian field action. Moreover, sophisticated computer-based GIS have been available for a longer time than the actual time length of their documented usage by humanitarian organizations. One of the challenges of NGOs and humanitarian organizations that have constrained projects for emergency deployment is exactly the usage of GIS platforms, which require guidance and a demanded entry user level (MapAction, 2011). Discrepancy between GIS knowledge and humanitarian field-workers that do not have training on GIS raise questions and could be further explored into an expansion of Web GIS usage and user inclusion.

Currently, more streamlined and user accessible tools make mapping technologies potentially useable by agencies and NGOs at field level, increasing the possibility of prototype implementation and community participation in VGI level.

Ideally, the type of GIS application explored in this paper would grant public access for further collaboration and interaction between different levels of target-users, ranging from the general public to users with prior geographical knowledge or field-workers in humanitarian response. Thus, the aspect of granting access and data upload raises several questions to be considered.

Naturally, quickly updated and real-time data come with the cost of validation, as there is little to no time for a professional to go over the data, which is made available in VGI platforms. This issue remains even stronger in the context of disaster relief, as it is an extremely time-sensitive manner. Although, there could be further authorization and authentication steps, preventing redundant or irrelevant information to be uploaded to this Web GIS application. Regarding the *aspatial* data aforementioned, there must be filters for social media information as uploads are constant and content can include basically any subject. Given this very example, Twitter provides several further authentication steps that can be successfully enabled in combination with geographical data (Appleby, 2012): in order to show information that is only relevant in given context, hash tags are used to catalog subjects currently under discussion and facilitating tag searching through the platform.

Other alternatives to filter Twitter content relevant to only disaster outbreaks in Valparaíso is using geographical data within the social media to sort out which Tweets would be shown in this application, using coordinates for geolocated Tweets as well as time zone, limiting the shown *aspatial* data to information provided within the city area. Keywords can also be used to distinguish relevant publications from other types. Filtering Tweets without media for improved loading times within web GIS applications is also worth discussing.

Regarding the geographical data uploaded in a potential public Carto profile, the challenge is slightly more difficult. Hence, the target user and the entry level of data provision have a positive correlation with the platform to which the data will be provided to be displayed in the application: though in Carto the filter for data is slightly more

challenging to be applied through code, it poses less necessary to be applied, as the application user who would make use of such has to have a prior geographical knowledge.

#### *Data upload and interoperability*

As interactivity and collaboration were part of the proposed usability results for this application, the data upload process was taken into account as the first step. Further, a more traditional approach of creating a GeoDatabase stored in a platform such as pgAdmin or MySQL would require storage space and a fast server to publish the layer data in the map frontend. Not only that, but it would require further developments to address accessibility and interoperability: different data formats would pose a challenge to implement, as metadata such as coordinates and system would have to be adjusted. Carto was found as an answer to both questionings, as it accepts several data types at the same time and has a very approachable upload method – drag and drop. Its interface allows the user to simply drag files – in extensions such as GeoJSON, ESRI file extensions and vector layer – lowering the user level of GIS expertise, which contributes for including the public into collaborating with the application, providing data.

#### *GIS in limited conditions*

Regarding access limitations in a disaster aftermath, Internet connection is the first priority of reestablishing after the disaster outbreak (UNDAC, 2013) but should be considered, as conditions are not usually optimal and tend to worsen in severe disaster impact. During a disaster outbreak, information resources can be even scarcer in developing nations. In developing countries, access to geographic data can oftentimes be challenging due to the copyrights established by the government and its natural research institutions (Leafer et al, 2006).

Carto as mapping platform, with connection to open source base maps – contains geographical *functions* including open street map and open source GI platforms. Though

useful and open source, using Carto with free access has limited functionality, where for more database space and functionality add-ons, it is necessary to subscribe paying a monthly fee. The fact that Carto can be used for free, even with limited usability, already presents an advantage and alternative to traditional system designs, as it can be used for small scale projects with smart planning, expanding the usability.

In larger scale projects with more data to be uploaded, as an example, in Carto, the limitations of a free account would pose a challenge and funding would need to be available if choosing to use all Carto's available functionalities and therefore expand its use to a larger group of users. Hence, due to the API use that also counts with limited access when using an account free of charge on Carto.

#### *Further development*

For further development, other implementation possibilities for this application could be considered. A feedback section within the map could be implemented, facilitating the process of keeping the data up-to-date: through disaster aftermaths, comments and feedbacks stored in the POI layer data as info windows, could provide accurate information about the very exact POI in the map, e.g. if such bus stop or hydrant is blocked or broken, or if such point of interest is not present anymore or moved to a different location due to the disaster outbreak. That would facilitate the user experience, informing authorities as well as possibly aid the field workers for humanitarian action planning.

The database portion of system design is to be considered regarding improvements and further development. While Carto presents advantages for GIS collaboration, to store feedback and comments from frontend to backend, perhaps a more traditional approach to system design could be implemented, so this data provided by the users could be stored using a completely open-source system design. Additionally, as previously mentioned, it would be interesting to carry out a user experience quantitative survey to evaluate what are the most and least useful aspects of the application, further implicating in the research of user experience and data for humanitarian deployment.

Also interesting would be a qualitative research with humanitarian institutions that do field work in natural disaster outbreaks to investigate why such GIS prototypes are not used often and what could be improved in their point of view. The routing could also be improved, as it now only accounts for cars or cabs within the town of Valparaíso. For expanded usability, routing regarding bicycles and public transportation would be useful in order to provide further information for people within the map locations to find refuge from areas impacted by natural disasters. An additional interesting interactive add-on that could be considered is Leaflet DRAW. This plugin for Leaflet allows the user to draw and edit vectors on top of the frontend map, that are saved in the Carto database as layer data. That could be particularly useful in humanitarian deployment or disaster aftermath regarding hazardous or severely affected zones, which could be added to the map in real time by low-entry users, providing accurate and data that is easy to interpret in real time, expanding interactivity.

#### *Other uses for the Application*

This Web GIS prototype offers adaptability to further uses when no disaster outbreak is taking place. Hence, not only as a resource of humanitarian geographical data to be used in mitigation and planning of any emergency event, but also can be modified or adapted into displaying smaller events that can be of the public's interest, strengthening communication between institutions and the general public. That is possible by the combination of social media and GIS, largely explored in the previous chapters, whereas official data providers would be able to provide and interact with the public in a more accessible manner, when compared to official geoportals.

## Conclusion

Humanitarian and disaster crises present logistics and coordination challenges, not only for field workers but also citizens involved in a matter where data and information oftentimes mean route to safety and primary needs sought. With the change and expansion of the Internet, GIS and Web 2.0 tools, it became easier to exchange information at real time virtually in the entire globe. Thereupon, the opportunity rose for geographic information to be implemented in time-sensitive issues, in which mapped information is a tool to facilitate communication and logistics planning, also involving the community.

As the VGI community and the need for data grows, there remains a need for exploring combinations of data interoperability and quality control, in order to have reliable Web GIS applications for disaster response. Different data sources can be integrated using available open source tools, using a lower user-entry level user base, which can be involved into humanitarian action and relief. Additionally, when GIS platforms are built for web and expanded uses to include community participation, usability is one of the aspects. Hence, its accessibility in the field to deliver the tools providing straightforward answers to the exact needs for disaster assessment and humanitarian help, even for citizens, proven to be crucial.

Technical developments of Web GIS present a great opportunity to balance out data quality and usefulness of a GIS application: data needs are to be adapted with available data and resources, including the target group. Further, the target group as the general public can be recognized as leverage for GIS integration with real time data: using smart social media tools to involve the community in information gathering, all involved can benefit from a quickly updated GIS platform for rapid aid deployment and guidance throughout an emergency.



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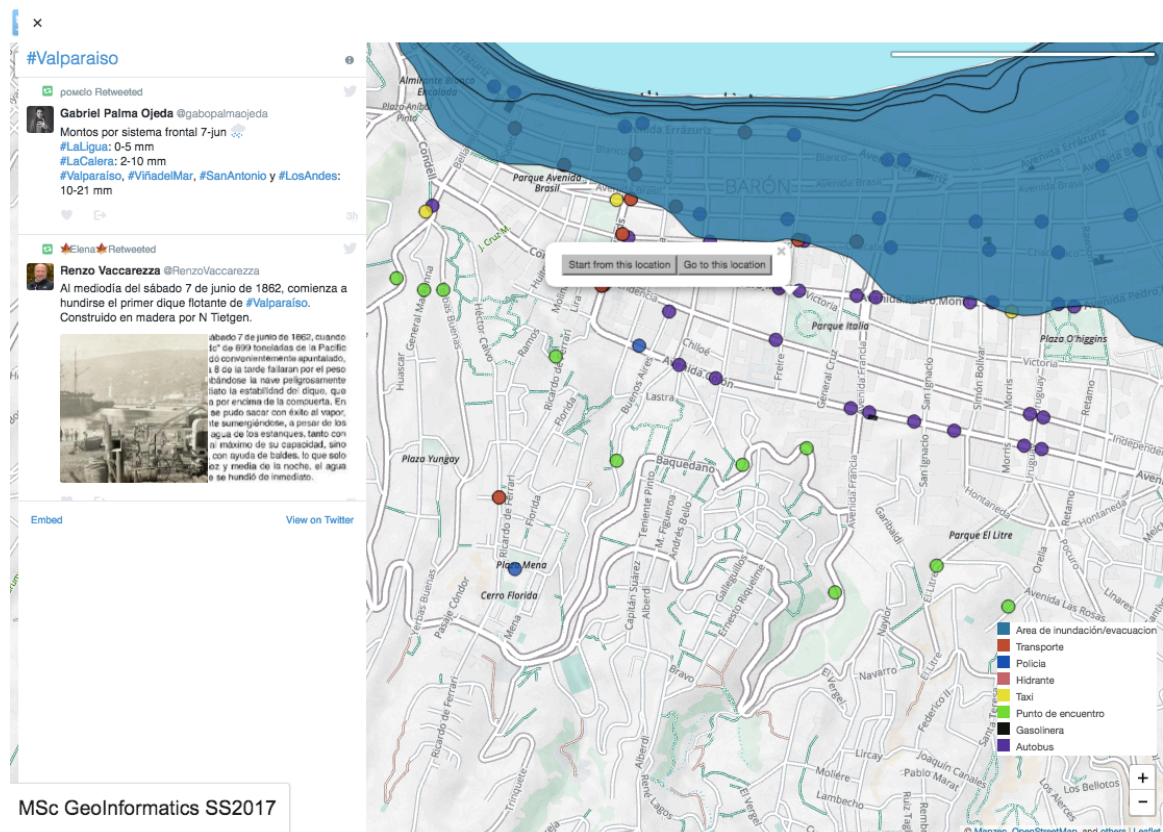
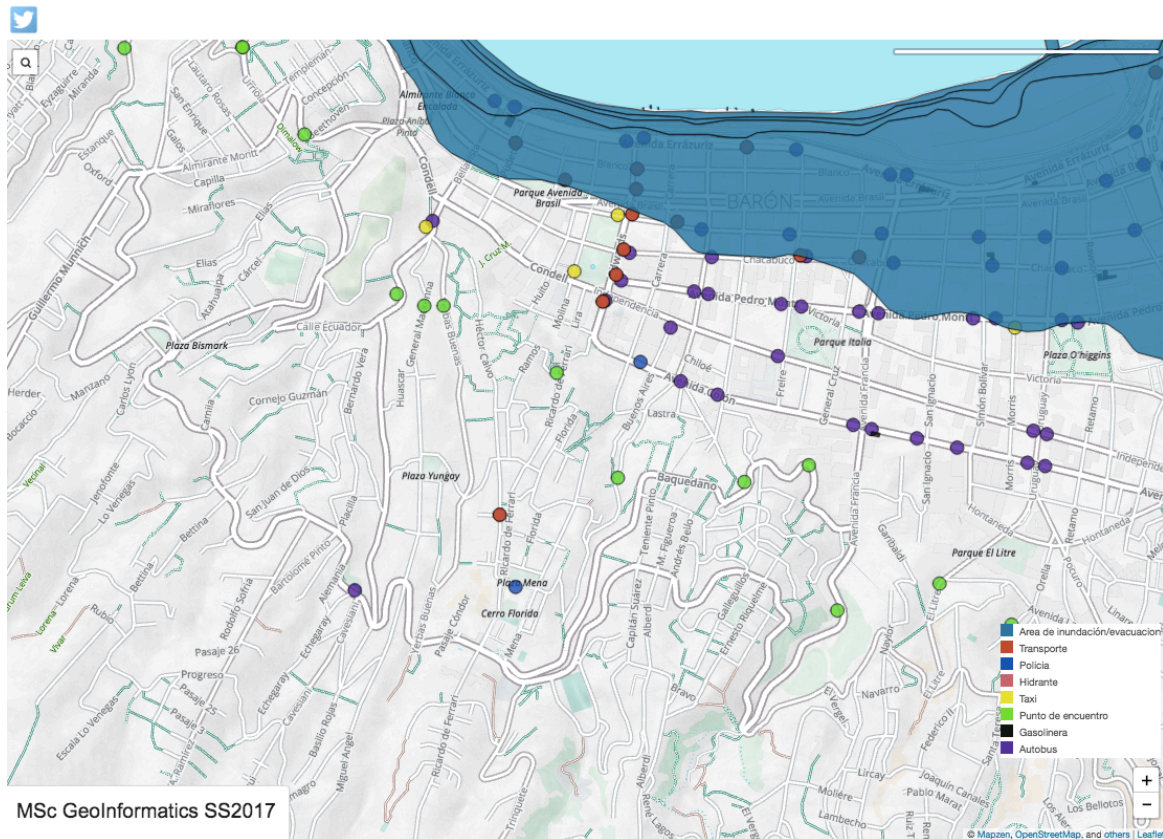
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## Appendix

### Annex A: Screenshots of the WebGIS app prototype



## *Annex B: Source code of the application*

```
<head>
  <title>AAU WebGIS App · MSc Geoinformatics 2017</title>
  <meta http-equiv="content-type" content="text/html; charset=UTF-
8" />
  <script src="https://unpkg.com/lrm-mapzen@1.1.7/dist/lrm-
mapzen.js" type="text/javascript">
  </script>
  <script
src="https://ajax.googleapis.com/ajax/libs/jquery/3.1.0/jquery.min.j
s" type="text/javascript">
  </script>
  <link rel="stylesheet" href="http://cdn.leafletjs.com/leaflet-
0.7.3/leaflet.css" type="text/css" />
  <link rel="stylesheet" href="../../leaflet/leaflet-routing-machine-
3.2.5/dist/leaflet-routing-machine.css" type="text/css" />
  <link rel="stylesheet" href="https://mapzen.com/js/mapzen.css"
type="text/css" />
  <link rel="stylesheet"
href="https://cdnjs.cloudflare.com/ajax/libs/semantic-
ui/2.1.8/semantic.min.css">
  <link rel="stylesheet" href="../../leaflet/custom.css" />

  <script src="http://cdn.leafletjs.com/leaflet-0.7.3/leaflet.js"
type="text/javascript">
  </script>
  <script src="https://mapzen.com/js/mapzen.js"
type="text/javascript">
  </script>
  <script src="https://mapzen.com/js/mapzen.min.js"
type="text/javascript">
  </script>
  <script
src="http://libs.cartocdn.com/cartodb.js/v3/3.15/cartodb.js"
type="text/javascript">
  </script>
  <script src="../../leaflet/leaflet-routing-machine-
3.2.5/dist/leaflet-routing-machine.js" type="text/javascript">
  </script>
  <style type="text/css">
```

```

/**]
    #map {
        height: 95%;
        width: 100%;
        position: absolute;
        z-index: 1;
    }
}
.custom .leaflet-popup-tip,
.custom .leaflet-popup-content-wrapper {
    background: #e93434;
    color: #ffffff;
}

.leaflet {
    line-height: 20px;
    color: #555;
    background: #FFFFFF
}
.leaflet i {
    width: 15px;
    height: 15px;
    float: left;
    margin-right: 8px;
    opacity: 1;
}

/*]]&gt;*/
&lt;/style&gt;
&lt;link
rel="stylesheet"href="http://libs.cartocdn.com/cartodb.js/v3/3.15/th
emes/css/cartodb.css" type="text/css" /&gt;
&lt;meta name="viewport" content="width=device-width, initial-scale=1"
/&gt;&lt;link
rel="stylesheet"href="https://www.w3schools.com/w3css/4/w3.css"
type="text/css" /&gt;
&lt;/head&gt;

&lt;body&gt;
&lt;section&gt;
&lt;div class="leaflet-bottom leaflet-left"&gt;&lt;div id="welcome-popup"
</pre>
</div>
<div data-bbox="851 936 886 955" data-label="Page-Footer">
<p>51</p>
</div>
```

```

class="user-info hide">
  <div class="ui segment">
    <h3>MSc GeoInformatics SS2017</h3>
    <div class="clearfix"></div>
  </div>
</div>
</div>
<div class="w3-sidebar w3-animate-left w3-margin-left"
style="display:none; overflow: visible; z-index: 2;" id="mySidebar">
  <button class="w3-bar-item w3-button w3-large"
onclick="w3_close()">&times;</button>
  <a href="#" class="w3-bar-item w3-button"></a><a
class="twitter-timeline" data-dnt="true"
href="https://twitter.com/hashtag/Valparaiso" data-widget-
id="861586770500222976">#Valparaiso Tweets</a>
  <script type="text/javascript">
    <![CDATA[
      ! function(d, s, id) {
        var js, fjs = d.getElementsByTagName(s)[0],
            p = /^http:/.test(d.location) ? 'http' :
'https';
        if (!d.getElementById(id)) {
          js = d.createElement(s);
          js.id = id;
          js.src = p +
"://platform.twitter.com/widgets.js";
          fjs.parentNode.insertBefore(js, fjs);
        }
      }(document, "script", "twitter-wjs");
    </script>
  </div>

  <div zclass="w3-main" id="main">
    <button type="submit" style="background-color:transparent;
border-color: transparent" onclick="w3_open();"></button>

    <div class="w3-container"></div>
    <script type="text/javascript">
      <![CDATA[
        function w3_open() {

```



```

        document.getElementById("main").style.marginRight = "30%";
        document.getElementById("mySidebar").style.width = "30%";
        document.getElementById("mySidebar").style.display =
"block";
    }

    function w3_close() {
        document.getElementById("main").style.marginRight = "30%";
        document.getElementById("mySidebar").style.display ="none";

    }
    //]]>
</script>

<div id="map"></div>
<script type="text/javascript">
    //
    L.Mapzen.apiKey = 'mapzen-hK1hfoN';
    var map = L.Mapzen.map("map", {
        center: [-33.035580, -71.626953],
        zoom: 16,
        tap: true,
        wheelPxPerZoomLevel: 40,
        tangramOptions: {
            scene: L.Mapzen.BasemapStyles.Walkabout
        }
    }).setView([-33.05, -71.62]);

    var geocoder = L.Mapzen.geocoder();
    geocoder.addTo(map);

    function onLocationFound(e) {
        var radius = e.accuracy / 2;

        L.marker(e.latlng).addTo(map)
            .bindPopup("Estás a " + radius + " metros desde
este punto").openPopup();

        L.circle(e.latlng, radius).addTo(map);
    }

    map.on('locationfound', onLocationFound);
</pre>
</div>
<div data-bbox="851 936 886 955" data-label="Page-Footer">
<p>53</p>
</div>
```

```

        control = L.Routing.control({
            waypoints: [
                null
            ],
            routeWhileDragging: true
        }).addTo(map);

        function createButton(label, container) {
            var btn = L.DomUtil.create('button', '', container);
            btn.setAttribute('type', 'button');
            btn.innerHTML = label;
            return btn;
        }

        map.on('click', function(e) {
            var container = L.DomUtil.create('div'),
                startBtn = createButton('Start from this location',
container),
                destBtn = createButton('Go to this location',
container);

            L.popup()
                .setContent(container)
                .setLatLng(e.latlng)
                .openOn(map);

            L.DomEvent.on(startBtn, 'click', function() {
                control.spliceWaypoints(0, 1, e.latlng);
                map.closePopup();
            });

            L.DomEvent.on(destBtn, 'click', function() {
                control.spliceWaypoints(control.getWaypoints().length - 1, 1,
e.latlng);
                map.closePopup();
            });
        });

        function getColor(fclass, featuretype) {

            if (fclass == "floodareas") {
                return "rgb(8, 118, 164)"
            }
        }
    
```

```

    }

    if (fclass == "emergencypoi") {
        return "rgb(209, 61, 28)"
    }

    if (fclass == "estaci_n_de_policia") {
        return "rgb(30,73,182)"
    }

    if (fclass == "hydrants_gjson_valparaiso") {
        return "rgb(212,91,102)"
    }

    if (fclass == "taxi_gsjon_valparaiso") {
        return "rgb(225,230,23)"
    }

    if (fclass == "meetingpoi_gjon_valparaiso") {
        return "rgb(23,230,50)"
    }

    if (fclass == "valparaiso_gjson_fuel") {
        return "rgb(16,23,17)"
    }

    if (fclass == "bus_gjson_valparaiso") {
        return "rgb(98,15,156)"
    }

    var letters = '0123456789ABCDEF';
    var color = '#';
    for (var i = 0; i < 6; i++) {
        color += letters[Math.floor(Math.random() *16)];
    }

    return color;
}

```

```
$.ajax({
```

```

url: "https://camilafraiz.carto.com/api/v2/sql?q=select
pg_class.relname from pg_class, pg_roles, pg_namespace where
pg_roles.oid = pg_class.relowner and pg_roles.rolname = current_user
and pg_namespace.oid = pg_class.relnamespace and pg_class.relkind =
'r'&api_key=202657682f20e069492d0d8cf31c837dce41d544"
    }).done(function(data) {

        for (var row in data['rows']) {
            layer = data['rows'][row]["relname"];

            console.log(layer)

            url =
"https://camilafraiz.carto.com/api/v2/sql?format=GeoJSON&q=SELECT *
FROM " + layer + "&api_key=202657682f20e069492d0d8cf31c837dce41d544"

            $.ajax({
                url: url,
                async: false
            })
            .done(function(layerdata) {

                console.log(layerdata)

                L.geoJSON(layerdata, {
                    pointToLayer: function(feature, latlng)
{
                        return new L.CircleMarker(latlng, {
                            radius: 10,
                            fillOpacity: 0.85
                        });
                    },
                    style: {
                        radius: 8,
                        fillColor: getColor(layer),
                        color: "#000",
                        weight: 1,
                        opacity: 1,
                        fillOpacity: 0.8
                    }
                }).addTo(map);
            })
        })
    })

```

```

        };
    });

    //]]>
</script>

<script>

function legendColor(item) {
    return item == "Area de inundación/evacuacion"
? '#0876a4' :
    item == "Transporte" ?
'#d13d1c' :
    item == "Policia" ? '#1e49b6' :
    item == "Hidrante" ? '#d45b66' :
    item == "Taxi" ? '#e1e617' :
    item == "Punto de encuentro" ? '#17e632' :
    item == "Gasolinera" ? '#101711' :
    item == "Autobus" ? '#620f9c' :

'#ffffff' ;
}

function zoomToFeature(e) {
    map.fitBounds(e.target.getBounds());
}

function onEachFeature(feature, fclass){
    layer.on({
        mouseover:highlightFeature,
        mouseout:resetHighlight,
        click:zoomToFeature
    });
}

var legend = L.control({position: 'bottomright'});
legend.onAdd = function(map) {
    var div = L.DomUtil.create('div', 'legend'),
        grades = ["Area de inundación/evacuacion",
"Transporte", "Policia",
"Hidrante", "Taxi",
"Punto de encuentro", "Gasolinera",
"Autobus"],

```

```

        labels = [];

        for (var i = 0; i < grades.length; i++) {
            div.innerHTML +=
                '<i style="background:' + legendColor(grades[i]) +
'"></i>' +
                grades[i] + '<br>';
        }
        return div;
    };
    legend.addTo(map);

</script>

<script type="text/javascript">
    //
        $(document).ready(function() {
            console.log("document loaded");
        });
    //]]&gt;
&lt;/script&gt;
&lt;/div&gt;
&lt;/body&gt;
&lt;/html&gt;
</pre>
</div>
<div data-bbox="851 936 886 955" data-label="Page-Footer">
<p>58</p>
</div>
```