Smart Urban Resilience:

Enabling Citizen Action in Disaster Risk Reduction and Emergency Response

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Smart City Technologies in Three Mexican Cities: Potential Contributions to Disaster Risk Reduction

Working Paper 5; Work Package 3

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I. Introduction

Technology can contribute to better cope with disaster situations, whether in the pre-disaster, during a disaster or in the reconstruction phase. In fact, the Sendai Framework for Disaster Risk Reduction 2015-2030, which contains general strategies for action signed by several countries within the United Nations, has 31 explicit references to the use of technology for disaster risk reduction. This framework for action emphasises the need to promote the transfer of technology between countries, as well as its use to map risk zones by region, analyse data to identify trends, as well as to install early warning systems.

Potential contributions have multiplied from relatively new technologies that have started to be used more widely, such as: social media, geospatial technologies, portable applications, drones, robots, visualisation technologies, sensing systems, internet of things, as well as end-to-end platforms and artificial intelligence. Their use is associated with benefits such as: improving information or communication flows; better understanding disaster-related behaviours; collecting, storing, analysing, and using accurate data for decision making, to name a few.

It should be added that civil society organisations are quite active stakeholders in this type of emergency situations. Moreover, they often use different types of technology to maximise the impacts of their interventions, regardless of whether they specialise in disaster-related issues or are involved in disasters on a temporary basis. The Sendai Framework itself recognises the need to use social technologies through participatory processes (Sendai Framework, pp 21). While such stakeholders may pursue their own agendas as they are not neutral players, there is a large body of literature that recognises the role that civil society organisations play in overcoming disasters (Buckland and Rahman, 1999; Nakagawa and Shaw, 2004; Dynes, 2005; Tatsuki and Hagashi, 2002; Kage, 2010; Aldrich, 2012). It is assumed that more organised societies have the ability to inform or communicate faster, as well as solve all collective action problems more nimbly (Aldrich, 2012).

This Working Paper studies disasters that occurred in three Mexican cities: Tropical Storm Ingrid and Hurricane Manuel in Acapulco in 2013; the September 2017 earthquake in Puebla; and the floods that occurred in the Querétaro Metropolitan Area and its tributaries in 2017. In the three cases studied there was some level of participation from civil society organisations. In this paper, the concept of civil society organisations incorporates organisations that pursue certain thematically delimited purposes, but also considers communities, *ejidos*, neighbourhood societies, or any other association that pursues broader purposes.

The first research question of the Working Paper is how did civil society organisations use technologies to deploy their strategies in the face of such events? The second question is what are the factors that explain the type of use given? The first proposition is that the use of technology in disaster contexts can increase the reach of organised civil society contributions. Social media can further streamline information flows; the use of sensors or applications by organised individuals allows for more accurate data collection about an event; the coordination of early warnings with evacuation protocols can minimise loss of life, to name a few examples. This dynamic implies that a ***synergistic pattern of use*** is generated, which magnifies the potential contributions of civil society as well as the technologies used.

However, the promises offered by technologies do not always materialise. Therefore, it is important to consider a second proposition that argues that sometimes organised action occurs on a regular basis, without the technologies making any significant difference. Basically, it is a situation in which the traditional functioning logic of this type of organisations is imposed, while some technologies are incorporated only as secondary aspects. This dynamic is referred to here as the ***pattern of secondary use of technology***.

The hypothesis proposed is that ***when collective action problems are relatively solved, organised civil society stakeholders can make maximum use of technology when they engage in some activity to address a disaster***. This is because, while mobile devices, ubiquitous internet access, social media, and the use of apps or sensors can be used individually, harnessing them for a collective strategy requires some degree of centralisation. As collective action among participating civil society organisations is solved, at least to some degree, this maximum leverage can be achieved, allowing the first pattern mentioned above to materialise.

In contrast, without interoperability standards, shared definitions, shared repositories and robust common infrastructure, the initiatives undertaken will be partial and incomplete approaches with limited ultimate utility. When this occurs, the second pattern tends to occur, in which the routine activities of social stakeholders in the face of disasters predominate, with limited incorporation of technology, in which they cannot deploy their full potential due to the absence of a backbone that articulates, harmonises, standardises, and systemically incorporates the information collected, which prevents much more precise reactions by these stakeholders in the face of disasters.

The Working Paper uses a comparative case study methodology that pursues literal replication of one of the two identified patterns. Literal replication occurs when similar results are obtained in different cases (Yin, 2002). It is important to note that the units of analysis are not cities, events, civil society organisations, or technologies. The unit of analysis is the use that civil society organisations made of certain technologies to deal with certain disaster situations. In this sense, these are *embedded case studies*, which have been defined as those in which the unit or units of analysis are sub-components or limited aspects that are part of the case in general (Scholz and Tietje, 2002).

Evidence of literal replication was obtained for the three cases studied. Specifically, we found limited use of certain technologies (social media, messaging applications, as well as specific applications. Furthermore, the use made of them was, in almost all cases, to improve communication flows between stakeholders seeking to cope with disasters. Furthermore, in all three cases, there was evidence that a ***pattern of secondary use of technology*** predominated, with none of the factors that increase the likelihood of collective action being present.

The Working Paper is divided into five sections. The first presents a general description of the events that occurred in the four cities studied. The second contains the literature review. The third section explains the methodology used. The fourth section presents the main results obtained. Finally, the fifth section presents some final reflections.

II. General Description of the Occurring Events

The Working Paper focuses on the events that occurred in three Mexican cities of similar size: tropical storm Ingrid and Hurricane Manuel in Acapulco in 2013, the September 2017 earthquake in Puebla, as well as the floods that occurred in the Metropolitan Area of Querétaro and its tributaries in 2017. However, as mentioned in the introduction, the case studied are not the events in general, but the use that organised civil society stakeholders, involved in the different phases of such disasters, made of different technological tools. The following is a general description of the events, the organisations involved in the events that occurred in each city, as well as some of the technologies used.

a. Acapulco

In 2013, as every year the rainy season was expected in Acapulco. This year there was one tropical depression, 11 tropical storms and 9 hurricanes, of which only one reached the category of major hurricane. On Thursday, September 12, tropical storm "Ingrid" was identified in the Gulf of Mexico 95 kilometres east-northeast of Veracruz. On Friday, September 13, the National Meteorological Service (SMN, as per its acronym in Spanish) reported a broad instability located 190 kilometres south of Acapulco, with a 60% probability that it would intensify into a tropical cyclone in the next 48 hours. That same day at 16:30 hours the tropical depression intensified to a tropical storm and was named "Manuel"(Mejía, 2014).

On Saturday, September 14, through a press release, CONAGUA [National Water Commission] (2013) reported that storm Ingrid intensified to a category 1 hurricane, and, according to its trajectory, would make landfall on September 16 between northern Veracruz and southern Tamaulipas (Gulf of Mexico). In addition, on the Pacific side, due to storm Manuel, the alert zone was maintained from Acapulco in Guerrero to Punta Telmo, Michoacán.

For that reason, CONAGUA (2013) urged the population to remain attentive to civil protection calls and to those who would spend the national holidays in tourist areas (September 16 long weekend due to the celebrations for the independence of Mexico), and recommended extreme caution in the sea and rivers, and in urban areas with probable risk of flooding. It is noteworthy that the SMN made available to the public a weather map and weather conditions by city, and together with CONAGUA invited to follow the information on Twitter and mobile application MeteoInfo. In the course of Saturday 14 and early Sunday morning September 15 rains intensified in the State of Guerrero.

On Sunday, September 15 at 00:00 hours, the La Sabana River began to overflow towards the Las Gaviotas housing development, about 6 km upstream from its mouth in the Tres Palos Lagoon. The overflowing of the river occurred after the first heavy rains in the area, apparently the riverbed lacked the necessary hydraulic capacity for the volume of water that occurred on September 14 (Mejía, 2014). Shortly after, at 01:00 a.m., the Papagayo River overflowed in the area of Lomas de Chapultepec, approximately 4 km from the mouth of the sea. At 5:00 a.m., the flooding of the La Sabana river advanced southward, covering part of the Llano Largo and Luis Donaldo Colosio neighbourhoods (Mejía, 2014).

The impediment of the outflow of the Laguna Negra to the sea caused the accumulation of water, flooding the COSTCO store, the Luis Donaldo Colosio neighbourhood, the golf course, and businesses on Revolcadero Beach. In addition, the increase in the water level in the mangrove swamp of the Laguna Negra caused it to overflow towards Puerto Marques (Mejía, 2014). On the other hand, the current of the Papagayo River collapsed the Barra Vieja-Lomas de Chapultepec auxiliary bridge, which was the access road to federal highway 200 Acapulco-Pinotepa and a smaller bridge that served as access from Barra Vieja to Lomas de Chapultepec (Mejía, 2014).

Some 500 people were moved to temporary shelters because in some neighbourhoods the water exceeded one metre in height, dragging several cars, the international airport was isolated, the Sun Highway was blocked by landslides and telephone and power lines were down (Excelsior, 2013). On September 16, the Metropolitan Zone of Acapulco (MZA) was completely cut off by land and air. There were more than 600,000 citizens affected and 40,000 tourists stranded; in addition, there were problems with telephone communication, internet, lack of banking services, increased garbage, and water shortages (Excelsior, 2013).

On September 16, 2018, a group of people affected by Ingrid and Manuel held a protest at the flagpole to ask the National Institute of Housing for Workers (Infonavit) to release the deeds and cancel the credits of the people who suffered damages. The president of the Coalition of Inhabitants Affected by Natural Contingencies (CHACN) reported that there were 35,000 homes affected by the floods and mentioned that in Neighbourhood Colosio the damage caused by the rains was still visible: buildings and the sewage system remained unrepaired and there were sewage leaks. The National Centre for Disaster Prevention (CENAPRED) warned that 96.4 percent of the houses were likely to flood again (El Sol de Acapulco newspaper, 2018).

Some of the social stakeholders that were involved in addressing the effects of these meteorological phenomena were: the Integral Institute for the Social Management of Disaster Risk and Climate Change, the CHACN, the organisation of neighbours of the Luis Donaldo Colosio Housing Unit, the community El Bejuco, the community La Barra, the Promoters of Self-Management for Social Development (CPADS), OXFAM Mexico, the Mexican Red Cross, as well as the area of engineering in disaster prevention and civil protection of the Universidad Autónoma de Guerrero (UAGRO). Finally, it is important to note that in Acapulco the use that these stakeholders gave to technology is reduced to social media or communication applications (WhatsApp) with the aim of communicating better before, during or after the occurrence of disasters.

b. Puebla

On September 19, 2017, the National Seismological Service (SSN) reported an earthquake with magnitude 7.1 located on the state border between the states of Puebla and Morelos, 12 km southeast of Axochiapan, Morelos and 120 km from Mexico City. The earthquake, which occurred at 13:14:40 hours, was strongly felt in the centre of the country. The coordinates of the epicentre are 18.40 latitude N and -98.72 longitude W and the depth was 57 km and until 18:00 hours of the same day 6 aftershocks had been recorded. As can be seen in the following map, the maximum intensities of the earthquake are in the region of the epicentre, between the states of Puebla, Morelos, and Guerrero.

Due to the occurrence of an earthquake of magnitude 7.1, the Ministry of the Interior (SEGOB) through the National Coordination of Civil Protection declared an Extraordinary Emergency for 112 municipalities in the state of Puebla (including the capital) based on the provisions of Article 26 of the Agreement establishing the Guidelines of the Natural Disaster Fund (FONDEN)[1], with this action, the resources of this Fund were activated so that the authorities and state governments had resources to meet the food, shelter and health needs of the affected population by providing food, water, mattresses, blankets, tools, medicines, sheets, etcetera. (SEGOB, 2019, September 19).

When the earthquake ended some professors of the Benemérita Universidad Autónoma de Puebla (BUAP), as well as the Universidad Popular Autónoma del Estado de Puebla (UPAEP) launched calls on social media (Facebook - Twitter) to assess the damage to buildings, or in the second case to organise collections to support the victims. The call was directed to their students, and also to other professionals in civil engineering or architecture who were interested in collaborating. In this initial phase, a few disjointed inspections were carried out in some delimited places in the centre of the city, or in some communities on the periphery.

The teachers who made the first calls through social media have long been activists in other issues related to seismic activity. For example, one of them has long offered training courses to masons on technical criteria for self-construction. Another participated in a Food Bank, as well as in the construction of houses made with ecological materials in devastated areas.

In a second phase, the two universities reorganised their initiatives and used the command structure of the universities, especially in the BUAP, the directors of the faculties of Civil Engineering and Architecture assumed the coordination and organised massive training workshops in which hundreds of volunteers participated and generated a format to carry out the review of buildings, both in University City and in the Centre where it has under its custody several historic buildings. The professors who first called for the mobilisation joined this second phase largely because of the reputation of university officials. On the other hand,

[1] Financial instrument through which the National Civil Protection System, through the Operating Rules of the Fund itself, integrates a process respectful of the competencies, responsibilities and needs of the various levels of government, which aims, under the principles of co-responsibility, complementarity, timeliness and transparency, to support the states of the Mexican Republic, as well as the agencies and entities of the Federal Public Administration, in the care and recovery from the effects produced by a natural phenomenon, in accordance with the parameters and conditions set forth in its Operating Rules (available at: https://www.gob.mx/segob/documentos/fideicomiso-fondo-de-desastres-naturales-fonden).

the College of Architects and the College of Civil Engineers of the entity coordinated with Civil Protection to also support the damage count and collaborated with their own format or guide to review the damage to the buildings.

Facebook and Twitter were used for training calls, as well as Whatsapp for internal communication. There were crews in charge of a qualified engineer who were assigned certain blocks to do the revisions, the rest of the members were non-qualified students. Sometimes efforts were duplicated because it was not clear the limits or areas that were in charge of a crew. The four groups involved (college of engineers, college of architects, BUAP, UPAEP) started acting in a certain way as independent cells to later, at some point, establish some coordination among them and with Civil Protection. In the second phase, there was never a digital platform that could aggregate the information or better coordinate the efforts of the participating volunteer crews. The forms were filled out on paper and many have been lost. There was no single digital repository with scanned forms.

Subsequently, a third phase occurred in which the federal government, through SEDATU (Secretariat of Agrarian, Territorial and Urban Development), took control of the real estate reviews. The universities, as well as the two participating schools, were asked to back up the information collected. However, the participants of the first two phases were not invited to continue carrying out these activities, as they would now be carried out by engineers hired by the government (one of the volunteers of the first phase joined this modality). Participants from the first two phases reported that they perceived the third phase as a displacement.

In Puebla, the use of technology was a little more extensive than in the other two cities studied. Here, social media were used to improve communication flows, messaging applications (WhatsApp) were also used, as well as specialised civil engineering applications that brigadistas installed on their cell phones.

c. Querétaro

The Querétaro River and its tributaries are the main arteries that receive a large part of the runoff from the city’s streams and rainwater. The drains and curbs that have been built as part of the city’s stormwater infrastructure connect with these arteries. The main feeder of the Querétaro River is the El Pueblito River, the municipal capital of Corregidora and part of the Metropolitan Zone of Querétaro (MZQ). In the Metropolitan Zone as a whole, there are 52 dams and dikes that collect runoff.

During 2017, 21 construction and preventive maintenance works were carried out on this rainwater infrastructure, with an investment of 100 million pesos. Paradoxically, during this year’s rainy season, heavy flooding and damages were recorded in the metropolitan area. On June 26, 2017, the arrival of heavy rains in the city was announced. On the 27th, it was reported that on Epigmenio González Avenue, several cars were trapped; in Cerro de las Campanas, trees fell on parked vehicles. There was also a landslide at kilometre 23 of the Fray Junipero Serra circuit.

In Jurica, 51 mm were recorded; in Santa María Magdalena, 39 mm; in Cerro de las Campanas, 38 mm; in the Escobedo Market, 33 mm; in the city centre, 27 mm; and in El Refugio, 11 mm. The rainfall caused flooding; the water currents dragged leaves, grass, and garbage, which caused blockages in the pluvial structures. Damage was reported in 6 homes in San Antonio del Maurel and in La Joya, in addition to water accumulation on Prolongación Zaragoza Avenue, in various streets of the Historic Centre and on 5 de Febrero Avenue. In the latter, cars could not circulate, because at the height of the Carrillo Puerto bridge the water stopped them.

On July 5, it was reported that heavy rains affected roads and left cars stranded on Bernardo Quintana, Epigmenio González and 5 de Febrero, and at the height of the Carrillo Puerto bridge. There were puddles on Carretas, on Allende and Zaragoza streets and on Prolongación Corregidora Norte – at the height of the skating rink – and on Guerrero and Zaragoza streets. Fernando Martinez Garza, General Coordinator of the Municipal Civil Protection Unit, reported that the Bolaños Drain and the Queretaro River, at the height of Santa Maria Magdalena, reached their maximum capacity without overflowing.

On July 8, Oscar Hale Palacios, president of the College of Civil Engineers of Querétaro, said: "All the works that the municipality has done are well done, we should not demonise these works, the problem is that we have a great deficiency of rainwater works, he had the good sense to even do these works in places with a large backlog of rainwater works. We have barely seven percent of the rainwater plan executed. So, at this rate if we are going to take a couple of years, encouraging that approximately 20 percent of public spending resources for public works, will be allocated to rainwater works."

On July 13, rains were reported the day before in the state territory and several municipalities were affected. In the city of Querétaro, the most affected area was Santa Rosa Jáuregui, which registered 41 millimetres of accumulated water, especially in the region of Montenegro and Juriquilla, as well as the Viñedos neighbourhood, located in the Carrillo Puerto delegation. It was also reported the presence of a landslide with a sinkhole in the asphalt of approximately four metres deep, at the entrance of the community of San Miguelito.

September saw the largest floods caused by the rains. One of the first was on the 5th, and as a result the roads were closed in Plateros, 5 de Febrero at the entrance to Jurica, Boulevard Bernardo Quintana, on the bridge connecting to the Querétaro River; there were also puddles in Carretas, at the height of Avenida Los Arcos. On September 7, the damage left by the rains in the Metropolitan Zone, caused by the passage of tropical storm Katia, is announced.

As a result of the rains and flooding, classes were suspended in 41 schools because 20 of these educational institutions could not access the buildings, and the rest were severely flooded. Between the 27th and 28th, it was reported in the newspapers that, due to the disaster caused by the rains, the municipal government of Querétaro would make an additional investment of 50 million pesos to address the new points of risk identified by the previous rain.

During the month of November, the efforts of the municipal government of Queretaro were focused on seeking alternatives to minimise the impact of disasters during the rainy season, which is why the approval of an insurance for homes was sought, according to a note dated November 9. That same day, progress was reported on the repair of the sinkhole in the access to the Antea Shopping Centre. In these efforts, the College of Engineers announced on November 10 the results of a study conducted in Jurica Pueblo at the request of the residents themselves, which indicated that the area was affected because three streams of water came from different sides: from the El Cajón dam, the stream that flows under the Nabo and Mompaní, as well as the El Arenal drainage.

In Querétaro, the use that these stakeholders gave to technology is reduced to social media or communication applications (WhatsApp) with the objective of communicating better before, during or after the occurrence of disasters.

III. Literature Review

There are different positions on the role of technology in disaster or emergency situations, but a good part of them see it as an unreserved good that promises better decision making, reduce economic losses, reduce damage to human life, property or infrastructure (Buckland and Rahman, 1999; Nakagawa and Shaw, 2004; Dynes, 2005; Tatsuki and Hagashi, 2002; Kage, 2010; Aldrich, 2012). We argue that technologies can have different uses such as: 1) making information flows faster, more accurate and comprehensive; 2) knowing in detail the behaviour of people in a disaster; 3) as well as collecting, storing, and analysing the data generated in such an event.

The uses to which technology is put in disasters hold some promise. For example, improved information flows imply the possibility of better diagnosis, reaction, and implementation of protocols throughout the different stages of a disaster: preparedness, occurrence, repair, and return to normalcy. Detailed knowledge of people's behaviours facilitates the implementation of future protocols that eliminate counterproductive behaviours, for example, when people do not take shelter in the appropriate places during an earthquake. For its part, data collection, storage and analysis hold the promise of open databases that will trigger future scientific research. The ultimate promise is a reduction of all the negative effects of such events.

Table 1 lists some of the most commonly used technologies in disasters, the use to which they have typically been put, as well as the promise they hold. The following describes the use that has been identified in the literature for each of these technologies.

Table 1. Expanded summary of technologies for DRR

Technologies	Main uses	Promises
Social media	o Supervision o Communication o Predictive models o Empirical analysis of disaster behaviour	Improved information and communication flows Improved situational awareness
Mapping and geospatial technologies	o Supervision o Predictive models o Reply o Recovery	Exploring disaster-related cultures and behaviours
Applications	o Communication o Supervision o Reply	Collect, store, and use accurate data
Drones and robots	o Supervision o Reply o Recovery	Enabling real-time monitoring and developing predictive models
Games and visualisation	o Communication o Disaster education	Promoting citizen perception
Detection and IoT	o Supervision o Predictive models o Communication	

	○ Reply ○ Recovery	
Integrated platforms and AI	○ Supervision ○ Predictive models ○ Communication ○ Reply ○ Recovery	

Source: own elaboration based on several authors

a. Social media

Houston et al (2015) have identified 15 different uses of social media in disasters and five different groups of users. The latter are: 1) individuals, 2) communities, 3) organisations, 4) governments and 5) media. Regarding the uses of social media, these include providing and receiving warnings, detecting disasters, sending and receiving requests for help, as well as discussing the implications of any particular disaster, and providing and receiving information about disaster response, recovery and recovery.

Social media is therefore useful throughout the disaster cycle and is seen as a key tool to enable those affected to participate more directly in DRR and emergency response. To a certain degree, social media also allows affected groups to express emotions, commemorate victims and thus discuss disasters beyond the moment of their occurrence (Houston et al., 2015, 14).

Studies of the applications of social media for DRR and emergency response, therefore, range from descriptive analysis of the behaviours of the affected population in disaster situations, to arguments about its use to make communication more efficient between authorities and the public, as well as within organisations and first responders. For example, it has been argued that the use of social media in times of evacuation is increasing and is shaping the way people make decisions, as information from social media is seen as more reliable (Ferris et al. 2016).

It has also been argued that commercial applications, such as Twitter, can be useful for improving the response of various groups, including government organisations, community groups, and disaster victims (Mills et al. 2009). Others argue that these platforms can improve the interconnection between authorities and public opinion (Vos and Sullivan 2014), although the amount of information shared by government officials and experts is taken up by the public depending on its origin. Finally, the use of social media among emergency response authorities can also be useful for identifying different institutional approaches to disaster management (Jungwon, Connolly Knox, and Kyujin 2018).

b. Mapping and geospatial technologies

The uses of geospatial technologies in disaster situations have been around for decades. Geographic Information Systems (GIS) have long been heralded as key tools to better understand disasters and enable more efficient DRR and emergency response (Cova 1999).

More recently, a shift towards supposedly more dynamic, transparent and decentralised forms of mapping has been identified (Kawasaki, Berman and Guan 2013).

Crowdsourcing and participatory mapping have been critically analysed, showing that these practices are fields where politics are at play (Petersen 2014, Brandusescu and Sieber 2018), intertwined with the inequalities that both precede, follow and are amplified by digital technologies (Givoni 2016, Gutiérrez 2019, Sullivan-Wiley, Short Gianotti and Casellas Connors 2019). However, there is still a deep divide between these critical approaches and the problem-solving spirit that drives most contributions derived from engineering and computing disciplines and fields.

Recent literature frames crowdsourcing, including mapping, as very promising tools for improving DRR and emergency response, enabling better knowledge and more efficient communication (Kankanamge et al. 2019). In that sense, crowdsourcing is an activity that should be encouraged through technological means, including the creation of ready-to-use platforms that allow citizens, volunteers and emergency services to interact and share information (Palen et al.2010, Ludwig et al.2017).

c. Applications (Apps)

A central concern among emergency response technology developers is how to enable information to reach people potentially affected by disasters more effectively. Some specific applications seek to provide disaster information as a service available to those who are part of these ad-hoc platforms. For example, Ludwig et al. (2017) have proposed the development of the “City - Share” application, which would provide a communication infrastructure for citizens, volunteers and emergency services to manage disaster offers and demands and emergency response activities on the ground.

Other applications are not intended for public use but are designed to enable better communication between first responders and personnel in command centres. This is the case with DistressNet, an “ad hoc wireless architecture” that links sensors, people and databases and shares information through mobile messaging and handheld devices (George et al. 2010). Applications are also proposed as solutions for post-disaster environments, allowing for better integration of infrastructures and, at the same time, taking advantage of the opportunity that disaster represents for the reconstruction and transformation of urban spaces.

This is, for example, the case of L’Aquila, Italy, where an information sharing app is seen as a way to improve public transport after the earthquake that hit the city, impeding mobility and putting pressure on public services (Falco et al., 2018). The notion that disaster is an opportunity to deploy different digital and smart urban technologies is present, either explicitly or implicitly, in other contributions (Marek, Campbell, & Bui, 2017), suggesting that disruption can be configured as a moment and space of transformation, even if the consequences of such changes are not yet fully clear.

The applications promise a seamless integration of various digital technologies with the aim of providing DRR and emergency response information and tools as a service to end users. Those mentioned so far include remote sensing, citizen detection, the use of databases and the transmission of real-time information through mobile technologies, operating at different scales.

There are other proposals that seek to operate on a global scale. Such is the case of the LastQuake platform and app (Bossu et al., 2018). Based on work conducted at the European Seismological Centre in the Mediterranean, LastQuake is a “multi-channel rapid information system” that includes a smartphone app. The app is designed to provide information to users gathered both through seismic sensor networks and through data extracted from Twitter via a bot. This second data set, provided by eyewitnesses, reframed as real-time sensors, is considered more accurate and timely than that collected by automated remote sensors, as has been argued in other studies (Earle, Bowden, and Guy 2012).

d. Drones and robots

Drones or robots have two main functions, the first is to enable remote command and control, particularly as the disaster unfolds. Both technologies allow responders to survey, search and rescue from afar, reducing the risk to which they may be exposed. The second function is to enable real-time detection and monitoring. This is particularly the case with drones, which offer the possibility of gathering information from a privileged aerial view.

Among these technologies, robots have a much longer history of use in disaster and emergency response. By the late 1990s, they were already being tested through events such as RoboCup, evaluating how they could be deployed in search and rescue operations, and developing standards for their design and construction (Kitano et al. 1999). Robots have also been used in real emergency situations. One example is the site of the collapse of the Twin Towers in New York City on September 11, 2001 (Davids 2002).

Drones are a more recent development, but this does not mean that their uses have not been explored in the technical literature. Their use is typically included as part of wider networks of digital technologies, including sensors, wireless devices, and visualisation tools. Their particular use comes from the fact that they are highly mobile and provide a wide “eye from the sky” view. Drones can be useful when conducting assessments, providing data to early warning systems, and providing evacuation support, among other functions (Erdelj et al. 2017).

If connected wirelessly, they can also enable more than observation and monitoring. They can be both a network of aerial sensors that provide real-time data to users accessing information through websites or apps (Quaritsch et al.2010), and they can also enable temporary mobile phone networks when these become operational (Hayajneh et al. 2016). Thus, drones promise more than just more efficient communication and more timely response. They are also described as tools that can make a system more resilient, understanding this concept from a technical point of view that does not necessarily imply regression to a previous order, but the ability to maintain flows and circulations in the face of unpredictable and sudden changes.

e. Games and visualisation

Disaster-related games and visualisation tools are two technologies that seek to bring future possibilities into the present, thus allowing decision makers, planners, potential victims, and first responders to better react when disaster strikes. These tools have different characteristics, so the relationship they establish with these speculative temporalities is not the same. Contributions analysing the role of gaming highlight the potential it has to improve awareness among international organisations, governments and non-governmental organisations (Gampell and Gaillard 2016).

These applications often distinguish between common games and specialised gaming platforms, which have been implemented in an effort to foster strategic foresight among key decision makers, such as the case of WeShareIt by Kenyan water experts and officials (Onencan et al. 2016). However, common games have also been analysed as they could be important tools for improving disaster education among users, which could generate greater awareness during disasters, although the link has not been explored in sufficient depth and detail (Gampell et al. 2017). Finally, it has been argued that games can be useful for introducing new conceptions of risk and hazard, particularly as the characteristics of disaster and disaster risk change due to environmental, demographic, and urban transformations (Yamori 2007).

Visualisation tools, on the other hand, are often part of broader technology interventions that seek to shape how DRR and emergency response are designed and carried out. For example, a survey of cloud-based technologies argues that visualisation can be a critical tool for improving access to relevant information in disaster situations (Ujjwal et al. 2019). Urban planners can use visualisation tools when designing and intervening in flood-prone cities by making the effects of potential disasters visible and tangible in spaces yet to be built. (Wang et al. 2019).

These ways of seeing can also be used when designing and predicting smaller-scale responses. For example, Park et al. (2018) call for a fire management system that uses augmented reality as a way to make the occupants of a building "visible and understandable." Here, the visualisation tool not only brings a future possibility into the present; it also engages in making a disaster, and those involved in it, more easily legible and therefore easier to act upon. This can be seen as a threat-centric notion of disaster that displaces the issue of vulnerability by advocating increasingly refined and complex technological solutions that can be implemented anywhere.

f. Detection and Internet of Things

This is a field where technology offers the possibility of gaining a better understanding of disasters by increasing the amount of data available, increasing the possibilities of automatically compiling and analysing it, and building networked architectures that are capable of containing the impacts of disasters and emergencies, regardless of their origin. It is assumed that on the basis of this accurate and real-time knowledge, there is a greater possibility of better reacting to a disaster as it unfolds. Again, here is a notion of disaster where issues related to efficiency, accuracy and speed of action can be resolved through more technology, and where end users would respond in a predictable manner as a result of the availability of more information.

On the issue of detection, proposals and contributions can be divided into two broad categories. The first comprises the issue of remote sensing, usually automated and linked to non-human objects and flows, including natural ones. In this field, two main applications have been developed. The first is early warning systems (EWS) which are based on the idea that sensors, connected wirelessly, can enable various groups to better understand how and when disasters and emergencies may occur. These sensors would monitor, analyse, and share information about various disasters, leading to a decrease in loss and damage (Rahman et al. 2016).

The second application is monitoring - mapping, for which sensors deployed both on the ground and on satellites are required, as the integration of data compiled on the ground and from above can result in more accurate data (Joyce et al.2009, Kaku 2019). For example, Chen et al. (2013) propose a specific architecture that integrates wireless remote sensing equipment to monitoring centres, allowing authorities to make better decisions.

The second category is the notion of citizen sensing or "people as sensors". As mentioned, studies suggest that user-transmitted information can be more accurate, more timely and responsive than that gathered through object detection (Bossu et al. 2018). Closely related to the notion of crowdsourcing, the idea of people as sensors deepens the distributed and ubiquitous logic of large-scale computing, sensing, and data presentation.

g. Integrated platforms and artificial intelligence

Integrated platforms, such as control rooms and dashboards, are key to integrating and coordinating information flows and response modes enabled by smart urban and digital technologies (Kitchin, Lauriault, and McArdle 2015, Kitchin, Maalsen, and McArdle 2016, Luque-Ayala and Marvin 2016, Marvin and Luque-Ayala 2017). However, in the technical literature on the specific topic of DRR and emergency response, these sites are largely absent. When mentioned, they are generally defined as a setting populated by first responders and victims (Vos and Sullivan 2014, Catarci et al. 2008, George et al. 2010).

In other contributions the aim is to do away with integrative platforms as an instance of data mediation and consolidation, as it is assumed that they could hinder efficiency and slow down communication flows. The aim is to create (often indistinguishable) device-to-device or person-to-person forms of communication through the use of wireless networks and sensors (Ochoa and Santos 2015, Kamruzzaman et al. 2017). In these cases the task of integration is moving from control rooms and dashboards to the automated technologies themselves. In this, Artificial Intelligence (AI) is crucial. For example, applications that use Twitter data to monitor disasters (Bossu et al. 2018, Zuo et al. 2018) rely on AI capabilities to extract, organise, analyse, and compile information.

h. The Dynamics of technology use

International initiatives have emerged in the form of "Frameworks for Action" which are general strategies for action shared by several countries. The evolution of these "Frameworks" reflects a paradigm shift from harm to risk reduction, as referred to by Gaillard and Mercer (2013). For example, the Yokohama Strategy (1994), as well as the Hyogo Framework for Action 2005-2015, aim to reduce the potential losses that disasters can cause to economic growth, development goals, the environment, human lives, and livelihoods. In other words, they are framed in a vision that involves concentrating efforts at the time the event occurs.

For its part, the Sendai Framework 2015-2030, which is the international agreement that seeks to shape DRR policy worldwide, postulates that the state is primarily responsible for disaster risk reduction, but also recognises the role that other stakeholders, such as local government, private stakeholders and civil society organisations, could play in this task - this is defined as a "whole of society" approach (UNISDR, 2015, 13). The Sendai Framework places particular emphasis on disaster risk reduction, as it seeks "the substantial reduction of disaster risk and losses in lives, livelihoods and health, and in the economic, physical, social, cultural and environmental assets of individuals, businesses, communities and countries" (UNISDR, 2015, 12). The emphasis on disaster risk rather than simply disasters reflects the shift in the way DRR is conceptualised and operationalised.

However, it is important to note that while the Sendai Framework has promoted a risk reduction approach to disaster management, this conceptualisation does not easily translate into practical action. As Gaillard and Mercer (2013) argue, hazard-focused approaches that assert "that disasters are the result of extreme and rare natural hazards, and that affected people fail to 'adapt' because their perception of the risk associated with these natural events is insufficient" (p. 93) have actually prevailed.

This means that, even if it is recognised that "disasters primarily affect those who are marginalised in everyday life and lack access to resources and means of protection that are available to others with more power" (p. 93), ways of tipping the scales of power and dynamics to better adapt, use and implement local ways of knowing and doing have not been developed. That is, even if the Sendai Framework develops a society-wide all-hazards and risk reduction approach (Aitsi-Selmi, Blanchard and Murray 2016a), practical ways to foster, promote and empower local actions, technologies and stakeholders have not been developed.

In addition to the focus on damage or risk, another aspect that has been widely discussed in the DRD literature is the participation of the different types of stakeholders involved. Particularly, on the one hand, there have been experts, scientists or technicians who have specialised knowledge, control technological instruments, and are generally the ones who direct governmental strategies. On the other hand, there are the stakeholders from the communities or civil society in which emergency phenomena occur, who have experience, the capacity to mobilise and first-hand information on what is happening.

There is an interesting proposal that integrates the two types of stakeholders (Gaillard and Mercer (2013). They suggest a reconciliation between different forms of knowledge and action, integrating different scales and reconciling bottom-up and top-down approaches (p. 94). In this proposal the authors propose different measures to bring together ways of knowing or doing that have been carried out separately. These include questions related particularly to the relationship between science, technology and action. The authors argue that even if it is increasingly recognised that local knowledge has value and useful lessons for providing DRR solutions, challenging the primacy of scientific knowledge, there is still a need to bring scientists and communities together when designing DRR policies and technologies.

An important argument of Gaillard and Mercer (2013) is that the successful incorporation of technology in DRR depends on it being the product of the amalgamation between the uses proposed by the techno-scientific vision, with those arising from the vision of the affected communities. Otherwise, the technology will never be internalised as part of communities' routine responses to such events, which will necessarily result in its failure. For example, if we imagine a strategy that involves the use of smartphones to map risk zones (crowdsourcing) the technology will be irrelevant without the massive participation of those affected. Even the installation of autonomous sensors will be unproductive if it is not accompanied by displacement protocols for people.

Civil society stakeholders are not neutral stakeholders, in fact, they often have an agenda of their own that they actively work towards. When a disaster situation arises, these agendas can be in competition with each other, at one extreme a situation can arise in which collaboration is impossible. The competition begins at the point when it comes to defining the most pressing problem(s) to be addressed. If the problem defined is one of housing reconstruction, organisations with experience in this type of activity will have a more relevant role than others. If, on the other hand, the problem is defined in terms of the need to distribute food, organisations with more members, as well as the capacity to mobilise or transport, will be the ones to take the lead.

Sometimes collective action is more likely to occur because of the size of the groups in which it occurs, sometimes because an individual organisation predominates over the others, sometimes there is a meta-organisation or organisation of organisations that articulates the actions; even another factor may be the participation of an external stakeholder with superior resources or capabilities; as well as the existence of positive or negative external incentives that encourage it (Oliver, 1993; Ostrom, 2010; Olson, 2012). When any of the situations described above is present, the incorporation of technology is more likely to be successful, because it is supported on top of a previously established cooperation structure, which produces a ***synergistic pattern of use***.

Technology is an external element that can reconfigure power relations among organisations involved in a disaster-related activity. As a result, it can shake the existing balances that make collective action possible. This is because, although many of the existing new technologies are for individual use (smart phones, social media, sensors, or applications, to name a few), they require a centralised structure in order to deliver their full potential. For example, to develop a georeferenced digital map in an earthquake, based on crowdsourcing, requires the massive participation of multiple smartphone users. However, the initiative will only make sense if there is an agreement on the type of information to be collected, clear criteria on the format of such information (photo, video, location), as well as a centralised platform where all the collected data is downloaded.

Therefore, it can be assumed that when some of the conditions that facilitate collective action are not met (it is a small group of organisations, one organisation does not predominate previously, there is no articulating meta-organisation, there is no external stakeholder that has the weight to promote collaboration, or there are no positive or negative incentives) the incorporation of technology ends up crystallising in a set of moderately isolated actions, in which its full potential is not realised. This scenario is what this Working Paper has called the *pattern of secondary use* of technology.

IV. Methodology Used

The methodology used in this Working Paper is that of comparative case studies that pursue the direct replication of some research hypotheses. In general, case studies are used when questions of how or why are raised, when there is little control over the events to be studied, or when the focus is on contemporary phenomena with some real-life context (Yin, 2002; 3). One of the strengths of this methodology is that it allows dealing with a wide variety of evidence, such as documents, data, interviews, or direct observations.

Another relevant feature is that case studies are preferred when dealing with contemporary events where some of the relevant stakeholders of the events can be accessed. Otherwise, when the stakeholders are not alive, the historical method is used in which the researcher must rely mainly on documents (Yin, 2002; 9). It should be clear that this method does not seek to make statistical generalisations regarding some universe or population, as statistical methods do. Rather, it seeks to generalise theoretical propositions according to Yin (2002; 9).

The use of this method is relevant when the boundaries between the phenomenon and its context cannot be unambiguously delineated. Not to mention that the variables with which an event is characterised are often proxies that may not necessarily reflect the complexity of a phenomenon (Yin, 2002; 13). In fact, in a case study there may be more variables than data, which is what happens when the case is supported by multiple sources of evidence. When the latter occurs, the "triangulation" of the evidence is pursued, that is, that all of it points in the same direction.

Case studies can be holistic when they focus on the entire phenomenon that occurred. They can also be embedded when the unit of analysis is a sub-component, or several sub-components, of the whole case. In addition, this type of study can be simple, when it deals with a single case, or comparative when it deals with several cases.

Research design is the logical sequence that connects empirical data to the initial questions of a study and to its conclusions. The design should consider what question to investigate, what data are relevant, what data to collect, and how to analyse the results (Yin, 2002).

The research design of a case study should consider the following components: the study questions, the unit or units of analysis, and the logic linking the data to the propositions, as well as the criteria for interpreting the data (Yin, 2002). In the case of this paper, the unit of analysis is the use of technology by civil society organisations involved in disaster-related activities. The data to be used will be those obtained from the interviews conducted in the three cities. Finally, the logic that links the data with the propositions, as well as the interpretation criteria, have to do with the similarity or difference of the interviewees' expressions with the two theoretical patterns that have been postulated (synergistic - secondary use).

In fact, according to Yin (2002; 26) an important strategy for interpreting findings is pattern matching which implies that many pieces of information from the same case are related to a theoretical proposition. To this end, it is common to posit patterns that are considered rival propositions. The case is expected to match one more than the other. It is not always possible to do some statistical test, so it is expected that the closeness with one of them is close enough to discard the rival pattern (Yin, 2002; 27).

Case studies allow for analytical generalisation. In statistical generalisation, inferences are made about a population or universe based on empirical data collected in a sample. In analytical generalisation, on the other hand, a previously developed theory is used as a template against which to compare the empirical results of the case study. When two or more cases support the same theory, replication can be said to have occurred (Yin, 2002; 32).

In comparative case studies, a “replication logic” is followed. “Literal replication” occurs when similar results are obtained. “Theoretical replication” predicts contrasting results for predictable reasons. When there are few cases, replication is usually literal (2 or 3 cases) (Yin, 2002; 47). If there are more cases (4 to 6), two different patterns are usually analysed. This Working Paper aims to carry out a literal replication based on the events that occurred in the three cities studied.

In order to collect the pertinent information, 69 semi-structured interviews were conducted. Of this total, 49 were carried out in one of the three cities covered in the Working Paper, while 20 interviews were conducted with companies, governmental stakeholders or civil society organisations related to the use of technology for disaster response, regardless of whether they were in any other location. Table 2 presents a summary of the associations interviewed, taking care to maintain the anonymity of their information. It is important to mention that for some groups more than one person was interviewed.

Table 2. Summary of interviewees of the research project

Acapulco	Puebla	Querétaro	Other
• Instituto Integral Para La Gestión Social Del Riesgo De Desastre (Integral Institute for Social Disaster Risk Management) • Promoters of Self-Management for Social Development (Promotores de la Autogestión para el	• Members of the College of Architects of Puebla [Colegio de Arquitectos de Puebla] • Members of the College of Civil Engineers of Puebla [Colegio de Ingenieros Civiles de Puebla] • Researcher at the Benemérita Universidad Autónoma de Puebla (BUAP) 1	• Neighbours of Santa María Magdalena • Neighbours of La Aurora • Organisation “Querétaro es Uno” (CSO) • Querétaro environmental activist • Neighbours of El Río • Neighbours of Jardines del Valle • Cinvestav Querétaro Researcher	• #Verificado19S (Different participants) • Biciteka Organisation • Digital Public Information Agency (ADIP) • Arise MX (Mexican Private Sector Network Alliance for Disaster Resilient Societies) • National Weather System (SMN) • Cisco Employee 1

Desarrollo Social or CPADS) • Organisation "Guerrero es primero" (Civil Society Organization) • Coyuca Neighbourhood • La Ceiba Neighbourhood • Colosio Neighbourhood • Del Río Neighbourhood • Red Maíz (Corn Network) • Red Cross • Union of owners of the tourist area of pie de la cuesta • Coalition of Inhabitants Affected by Natural Hazards • Researcher at the Universidad Autónoma de Guerrero • Public official of the Secreteriat of Urban and Territorial Development (SEDATU).	• Researcher at the Benemérita Universidad Autónoma de Puebla (BUAP) 2 • Researcher at the Universidad Popular Autónoma del Estado de Puebla (UPAEP) 1 • Researcher at the Universidad Popular Autónoma del Estado de Puebla (UPAEP) 2 • Student Participant in the Puebla Real Estate Supervision Initiative 1 • Student participant in the Puebla Real Estate Supervision Initiative 2 • Former Public Official of the Government of the State of Puebla • Public Official of the Government of the City of Puebla	• CIAQ Network • Querétaro Council for Science and Technology (CONECYTQ) • Jardines del Valle Residents • CINVESTAV Querétaro Researcher • Queretaro Planeado Forum • HidroJuricas	• Cisco Employee 2 • Civil protection officials in the three cities studied

Source: own elaboration

V. Results

The results obtained from the semi-structured interviews conducted for each of the disasters that occurred in the three cities studied are presented below. It is appropriate to remember that the first question posed is how did civil society organisations use technologies to deploy their strategies in the face of the disasters studied? The second question is: What are the factors that explain the type of use given?

As noted above, existing new technologies are for individual use (smart phones, social media, sensors, or applications, to name a few), and require a centralised structure to be able to offer their full potential. For this reason, any civil society initiative that involves the use of technology will only make sense if there is an agreement on the type of information to be collected, clear criteria on the format of such information (photograph, video, location), as well as a centralised platform where all the data collected is downloaded, to name a few aspects.

a. Acapulco

In Acapulco it was possible to verify that traditional telephones, social media, or messaging applications such as WhatsApp were used. A member of the Red Maíz declared that:

> "the only thing (we used) was the phone where the call didn't come in and we went directly, but we were also monitoring who was in charge, on the one hand, who was supporting us and how we were supporting them, after all that we met and the person who was in charge..." (Red Maíz member).

On the same lines, one CPADS member noted that:

> "Most of the communities had or still have telephone booths, in some, in the more distant ones there were almost none, very few people had telephones, I don't remember, I think they had phones with Telmex. But now communication is becoming more fluid, most of them have access to cell phones, the signal has reached a little more..." (CPADS).

In the Coyuca Community they explicitly mentioned the use of social media, specifically stating that:

> "...the commissioner, he is on *Facebook* and he is also in a *Whatsapp* group that people use to provide help, so that he can give us information on *Facebook*..." (Community of Coyuca). This same interviewee stated that: "...we found out one or two hours before when the water got into other neighbourhoods because they were on Facebook talking about it..." (Coyuca community).

A State Civil Protection official was also interviewed, who mentioned that:

> "...the bulletins are sent, that's why I say that, if technology is useful to us, because it makes our work easier, they started to send the bulletins, through the Whatsapp groups we have...".

The same State Civil Protection official said:

> "I also have a Whatsapp group of directors of Civil Protection in this region, I also have the municipal presidents and in that group I have other agencies such as SEDENA (National Defense Secretariat), CONAGUA (National Water Commission), as all agencies that help us ...".

The above quote demonstrates the multiplicity of existing communication groups, without this instrument being centralised. This public official also mentioned that:

> "Now on Facebook, each town has its own page, so-and-so has his page, so that information and these bulletins can be uploaded to those pages and people can find out little by little...".

Finally, a member of the Coalition of Inhabitants Affected by Natural Hazards stated the following:

> "I used Facebook, that's where I found out that it was still raining and there was no official communication from the government and I trusted it, but if it was Facebook that I was using..."

The evidence collected points to a limited use of technology by social or community stakeholders in the area. In addition to the fact that few technologies were used, it is confirmed that there was a pattern of secondary use of these technologies, as described in the Literature Review section.

Puebla

The review of homes in Puebla also identified the use of social media, messaging applications, as well as some civil engineering applications. A member of the UPAEP mentioned that:

> "our means of communication with the community, well with both communities, was through WhatsApp, that's what allowed us to organise in a way, well I think better with the whole issue of work..."

> "We made WhatsApp groups for all of us who were working on the reconstruction project and there we agreed on what day we would go, when we would go, who would go, who would not go, all this part of the organisation, the logistics of the transfers, we resolved it through this means..."

In the same sense, the Management of the Historic Centre of Puebla stated that:

> "After the seismic event, social media, Whatsapp and digital media became the primary mechanisms of information and help that civil society used to report damages..."

Similarly, one of the BUAP researchers who participated in the brigades of real estate review noted that:

"...I put out the call on Facebook and well, obviously the students, it's their normal and natural medium and it's how I engage them, I usually have a lot of interaction with them on Facebook, so, that's how I started to make my application..."

For his part, one of the BUAP researchers describes how some specific applications were used for their activities:

"GPS, in communities where there is no internet and no signal, we found applications that allowed us to geo-reference where we were, precisely which house we were in and, above all, to take pictures and with the geo-reference data and put the names, identification, that helped us a lot for the issue of documentation and as I say, we were finding, because we were looking for how to geo-reference, how to locate them..."

Regarding the way in which the collective action materialised, the Association of Civil Engineers of Puebla pointed out the following:

"There was a lack of coordination at a general level with other institutions that also participated and it did generate a certain amount of chaos, but with respect to the College, which is almost always the same, the same group that participates in this type of situation is almost always the same, well, more or less the organisation was adequate...."

Another member of the Puebla College of Civil Engineers stated that:

"Certainly, there was some confusion as to whether they were habitability reports, whether they were studies that required greater depth, but at that time, we finished organising the brigades to start the visit and we tried to have one more engineer, with more experience at the head of each group..."

A third member of the College of Civil Engineers de Puebla mentioned the following:

"Yes, we coincided in terms of work with other schools in the same and with other institutions in the same properties and well, if some parts did not coincide the opinions, also, later, well it was at the beginning, I do not remember exactly, how long we were working, but yes, about a week, in constant force, in the morning and in the afternoon..."

According to the College of Architects, different organisations regularly interact on such issues, although without formal coordination between them:

"We are also collaborating, College of Engineers, College of Architects, the University of UPAEP, Popular Autonomous University of Puebla, the University is doing an initiative where they are proposing, we'll call it, a software ..."

In the same sense, a BUAP researcher mentioned that:

> "they (the students and engineers) organised themselves, so they were there dividing themselves, in which crew each one was going to be, so, the self-management of the students also counted a lot, without a doubt..."

As with Acapulco, it can be seen that primarily social media were used, as well as messaging applications. However, in this case, due to the specialisation of the participants in the housing review initiative, specialised applications for civil engineering were also used. It is also confirmed that there was a pattern of secondary use of these applications, with multiple evidence of the lack of centralisation of the technology used in the implemented strategy, as well as of coordination among the participating stakeholders.

Querétaro

In Querétaro, social media were also used, as well as messaging groups, as can be seen in what was said by the residents of La Aurora:

> "We upload information to Twitter, to Facebook, on WhatsApp, to the polygon, so that they are aware".

> "To start with WhatsApp which is our first, our first application, it's the first one we use and from there we moved on to Facebook and some have Twitter, I manage Twitter, so, some things we need to get a response, like a water leak from CEA or park maintenance, by Twitter and we get a quicker response..."

> "We've been more or less in a group that is from Aurora and Jardines del Valle and Habitacional Santa Magdalena, we are like several neighbours who are in the same group. So, now that I am in that group, every time it rains, the Aurora neighbourhood committee starts to investigate the situation, they start to upload photos of the streets, to report where the water has already risen...".

The same was asserted by the residents of Santa María Magdalena:

> "I had contact with the neighbourhood representatives and they, in turn, communicated with their people, by WhatsApp phone, they made their groups..."

> "The subdelegate made a Facebook group and a WhatsApp group, and there he warns us or tells us when there is danger, well, those of us who wanted to join the group..."

> "Right now the most basic and what we use the most in the family or with other neighbours to communicate is WhatsApp. In terms of information we obviously do follow up on social media, more on Twitter, not so much on Facebook, and we also rely on the emergency line...".

There are also multiple citations of the disjointed use of technology during disasters. Apparently, the problem of collective action has not been resolved, which means that it is not possible to obtain the maximum benefits from the technologies used. In this regard, a resident from Jardines del Valle mentioned:

> “Each neighbourhood has its committee, as I understand it, these citizen representation committees are recent and the intention is that, through the committee, the neighbours manage the works and resolve the needs of the neighbourhood, it is a representative group like the neighbours’ association, but these committees work directly with the municipalities...”

> “No, not really, although we are in communication with Aurora, there is no joint work as such, everything stays in the neighbourhood of one or two people, it is not a group work with group, which is one of the things we are looking for now that, precisely, as committees we can do a bigger job for the area...” (Neighbourhood Jardines del Valle)

A similar statement was made by a member of St. Mary Magdalene Parish Council, who stated the following:

> “There is no organisation that coordinates the neighbours at the time of the floods, in reality it is something spontaneous” (Parish Council of Santa María Magdalena).

VI. Final Thoughts

It can be affirmed that a literal replication was obtained in the three cases studied. A limited use of certain technologies is found, particularly: social media, messaging applications, as well as specific applications (only for Puebla). The use of technologies is almost exclusively to improve communication flows between stakeholders who sought to cope with disasters. Overall, this answers the first research question posed herein.

Regarding the second question, it should be mentioned that more case studies are needed to increase the reliability of the results found. However, in the disasters in the three cities studied, evidence was found of a secondary pattern of technology use, which occurs when the traditional operating logic of the organisations is imposed, while some technologies are incorporated only as secondary aspects.

Evidence was found that supports the hypothesis, since in none of the three cases were there conditions that facilitated collective action, for example: that it was a small group of organisations, that one organisation was previously predominant, that there was an articulating meta-organisation, or that there was an external stakeholder with the weight to foster collaboration. Therefore, the incorporation of technology culminated in a set of fairly isolated actions, in which its full potential is not realised.

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