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Using Web-GIS Vicon as a Risk and Disaster Communication Tool[1]

A utilização do SIG Web Vicon como ferramenta de comunicação de risco e desastre

El uso de SIG Web Vicon como herramienta de comunicación de riesgos y desastres

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Abstract: Risk and disaster management involves a large amount of data that needs to be collected, processed, and analyzed to become information that results, therefore, in measures to reduce risk and damage. Therefore, this study aims to describe how the macro processes of risk and disaster management are supported using Geographic Information Systems in the Web platform (SIG Web). More specifically, the use of SIG Web VICON as an alternative to improve risk and disaster management actions, especially in the context of disaster risk assessment and communication by the protection and civil defense agencies in Brazil. The contribution of information that the tool provides for the identification, monitoring of threats, response actions, and characterization of vulnerable populations, makes VICON an instrument with high potential to support reducing the impacts caused by disasters.

Keywords: Geographic Information Systems, Risk management, Disasters, Communication, Emergency communication systems.

Resumo: A gestão de risco e desastres envolve grande quantidade de dados que precisam ser coletados, tratados e analisados, a fim de se transformar em informação que resulte em medidas eficazes de redução de riscos e prejuízos. Assim, este estudo pretende descrever como os macroprocessos da gestão de riscos e desastres são apoiados pela utilização de Sistemas de Informação Geográfica na plataforma Web (Web Gis),

1 This results were already partially presented at the I Seminário Paranaense de Pesquisas em Redução de Riscos de Desastres - SEREDE, in November 2018, named as *O uso do Sigweb Vicon como ferramenta de apoio a gestão de riscos de desastres na defesa civil de Curitiba-PR*

com o uso do SIGweb VICON como alternativa de aprimoramento das ações de gestão de risco e de desastres, especialmente no âmbito da avaliação e comunicação de risco de desastres pelos órgãos de proteção e defesa civil no Brasil. O aporte de informações que a ferramenta fornece para a identificação, monitoramento das ameaças, ações de resposta e caracterização das populações vulneráveis, torna o VICON um instrumento com alto potencial para apoio na redução dos impactos causados pelos desastres.

Palavras-chave: Sistemas de Informação Geográfica, Gestão de riscos, Desastres, Comunicação, Sistemas de comunicação de emergência.

Resumen: La gestión de riesgos y desastres implica una gran cantidad de datos que deben recopilarse, procesarse y analizarse para convertirse en información que resulte, por lo tanto, en el desarrollo de medidas efectivas para reducir los daños y perjuicios. Por lo tanto, el objetivo principal de este estudio es describir cómo los macroprocesos de gestión de riesgos y desastres se apoyan en el uso de Sistemas de Información Geográfica en la plataforma Web (SIG Web). Más específicamente, el uso de SIG Web VICON como una alternativa para mejorar las acciones de gestión de riesgos y desastres, especialmente en el contexto de la evaluación del riesgo de desastres y la comunicación por parte de las agencias de protección y defensa civil en Brasil. El aporte de información que la herramienta proporciona para la identificación, monitoreo de amenazas, acciones de respuesta y caracterización de poblaciones vulnerables, hace de VICON un instrumento con alto potencial de apoyo en la reducción de los impactos causados por desastres.

Palabras clave: Sistemas de Información Geográfica, Gestión de Riesgos, Desastres, Comunicación, Sistemas de Comunicación de Emergencia.

INTRODUCTION

The accelerated urbanization process in the world, especially since the 1960s in developing countries, coupled with the demographic growth of the population and the lack of planning for the occupation of the territory, aggravated the historical picture of inequality and social exclusion. The reflection of these actions was in the form of space occupation. More and more areas susceptible to natural phenomena such as floods have been occupied, making disasters frequent in cities. One of the necessary steps to reduce the risk of disasters is to improve the resilience of the system and society. The provision of information that enables risk awareness can help achieve this objective (FONSECA; GARCIAS, 2020; 2021).

To this end, it is necessary to develop methods, technologies, and tools for the adequate, rapid, and effective communication of information on flood risk between decision-makers and the public. Its usefulness is directly related to its ability to present information relevant to the citizen's location. Furthermore, the content and design of the tool need to be adjusted to the needs of users. Thus, the dissemination and communication strategies adopted influence people's access and understanding of information about natural risks. A web geographical information system (Web GIS) can be developed to minimize this gap. It allows the visualization and easy consultation of a complex hazard and risk database and, thus, allows interested parties to increase knowledge about disaster risk, making

them more capable of responding properly during the occurrence of an event extreme. The goal, therefore, is to encourage new disaster risk management practices.

In Curitiba (capital of Paraná State, Brazil), the Municipal Civil Protection and Defense Coordination (Coordenadoria Municipal de Proteção e Defesa Civil [COMPDEC]) was created by municipal law No. 6,725 / 1985 and, even though the agency has information technology, information, and communication, risk, and disaster management in the city are still limited. Furthermore, although urban planning actions have been developed that indirectly contributed to minimizing the risks of disasters, such as the elaboration of its first Master Plan in 1966 and the creation of its first parks in 1972 (Barigüi, São Lourenço, and Barreirinha) and 1978 (Iguaçu) (Oliveira, 1996; Secretaria Municipal de Meio Ambiente [SMMA], 2008), the city also shares with other urban agglomerations problems that aggravate and make the damages and losses associated with disasters frequent. Between 2006 and 2017, for example, 160 occurrences related to extreme events in the city were recorded (Coordenadoria Municipal de Proteção e Defesa Civil [CEPDEC], 2018). Most of them are associated with the occurrence of flooding, gales, and hail, which affected more than 500 thousand people and added losses of around four million reais (CEPDEC, 2018).

Based on this circumstance, and on the need to strengthen communication as a tool for disaster risk management and reduction, the present paper has as its main objective to evaluate Geographic Information Systems (GIS), more specifically those available on the web platform (Web GIS), as a tool for improving and communicating risk management strategies (prevention, mitigation, preparedness) and disaster management (response and reconstruction). For that, it is suggested the use of VICON (Surveillance and Control System) Web GIS as an alternative capable of assisting planning, management, and, especially, disaster risk communication by COMPDEC of Curitiba.

To advance in the analysis, it is first necessary to understand some concepts related to risks and disasters in urban areas and GIS's role in this scenario.

RISKS AND DISASTERS IN URBAN ENVIRONMENTS

Threats (natural or man-made), such as floods, deforestation, landslides, hurricanes, and fires, are potentially harmful processes or phenomena that can cause serious socio-economic damage to the social groups exposed to these events (Pelling et al., 2004). Whenever there is an interaction between natural or man-made threats and human systems, generating damage and/or damage that goes beyond the affected society's ability to recover using its resources, we are dealing with a disaster. Although there is still no fully accepted definition of what a disaster is, this type of event is always associated with losses, whether economic, social, or environmental (Quarantelli, 2006).

Before the realization of a disaster, however, there is a risk, which can be interpreted as the probability of adverse consequences or losses resulting from the interaction (Pelling et al., 2004) between the threat and the vulnerability of human systems. Society and/or its physical structures may be exposed in different ways to the same threat. Such exposure

is not restricted to the economic conditions of a given community, but also refers to the social, cultural, and environmental factors specific to the social group.

Although cities have conditions for economic development, technology, and innovation, these spaces can also become elements that generate risk. The growth of urban populations combined with the concentration of resources, weak local governance, inadequate water resources management, the deterioration of infrastructure, the existence of uncoordinated emergency services, corruption, the decline of ecosystems, the traffic of influence in the sphere politics and the adverse effects of climate change have made communities more vulnerable to threats and, therefore, to the occurrence of disasters.

UNISDR (International Strategy for Disaster Reduction, 2009) defines the concept of vulnerability as the set of processes and conditions resulting from physical, social, economic, and environmental factors that increase the likelihood that a given population group will suffer from the adverse impacts of a threat. It is important to note that the vulnerability is extremely dynamic and varies significantly within a community and over time. Thus, we can say that the concept of vulnerability reflects a quality of the moment, that is, a current condition. To reduce vulnerability, it is not enough to invest in changing the quality of facilities and building houses in safe places, it is necessary to increase the population's perception of risk and their degree of resilience before, during, and after a disaster situation (Fonseca; Ferentz, 2020, 2021).

In this context, resilience should be seen as a broad concept, which is not only linked to the capacity to respond, that is, to the actions taken after the disaster, it also involves the ability of communities to resist, absorb, accommodate, and recover from efficiently, preserving and restoring their essential basic functions and structures (Unisdr, 2009).

CONCEPTS ASSOCIATED WITH RISK AND DISASTER MANAGEMENT

Although it is not possible to prevent all impacts resulting from disasters, strategies, and actions capable of reducing their scale and severity can be adopted, that is, mitigating them (CEPED-UFSC, 2011). For this, companies must establish strategies for managing resources and responsibilities, before, during, and after the occurrence of this type of event. In the study area, "management" translates the broad knowledge to be acquired about the processes of prevention, reduction, response, and recovery, whose objective is to reduce the negative consequences or potential losses that arise from disasters. Thus, generating knowledge about the disaster in its different areas, preventing new risks, and reducing existing ones are some of the essential processes in disaster risk management (Narvaéz, Lavell & Ortega, 2009).

Over the past few years, a significant effort has been made to build a risk management practice in Brazil, and not just disaster management, to expand the organization and management of resources and responsibilities beyond actions response (CEPED-RS, 2016). Historically in Brazil, the topic of disasters has always been associated with the response actions taken by the Civil Defense, which plays a relevant role in the country in the legal

and technical development of discussions around the theme. Initially, Civil Defense grouped the risk and disaster management processes into four stages: prevention, preparation, response, and reconstruction. However, after the enactment of Law # 12,608/2012, which provides for the National Civil Protection and Defense System, they were updated, namely: prevention, mitigation, preparation, response, and recovery (Brasil, 2012).

GIS AS A TOOL TO SUPPORT RISK AND DISASTERS MANAGEMENT AND COMMUNICATION

The complexity of the risks and disasters and the number of variables involved make it practically impossible to treat data and information related to disaster risk management in the urban space using only analog and/or traditional methods (Marcelino, 2008). In this context, the use of technologies, especially geotechnologies, web mapping applications, and geographic information systems, can significantly support the design, execution, and evaluation of disaster risk management macro processes, especially in the pre-event phase. Geotechnologies can be understood as a set of technologies for collecting, processing, analyzing, and offering information with geographic reference (Rosa, 2005). Such technologies have been widely used in studies of prevention/mitigation, preparation, response, and reconstruction/recovery of environments affected by disasters (Cutter, 2003), especially those represented by Geographic Information Systems (GIS). GIS emerged as a solution to store, manipulate and generate graphic outputs from the large volume of existing geographic information, coming from different sources (Lacruz & Sousa Filho, 2009). One of the main characteristics of this system is the dual nature of the information: geographical data has a geographical location and descriptive attributes (Instituto Nacional de Pesquisas Espaciais [INPE], 2006).

Thus, the use of a GIS allows the user to consult and answer questions related to "what, why, how, where how long, and/or at what intensity" a given event or phenomenon develops in the geographical space. Davis and Câmara (2001) also emphasize that when performing computational processing of geographic data and retrieving information, not only based on their alphanumeric characteristics, but also through their spatial location, GIS offers the administrator (urban planner, planner, engineer) an unprecedented view of their work environment, in which all the information available on a given subject is at their fingertips, interrelated based on what is fundamentally common to them - the geographical location (Davis & Câmara, 2001).

In this context, the importance of using GIS-based geotechnologies by local managers is present in the main stages of the risk and disaster management cycle, as described by Marcelino (2008), prevention focuses primarily on risk assessments. The geoenvironmental data that can be obtained with the help of satellite and GPS images are transformed into information plans in the GIS. In preparation, moments before impact, geotechnologies are used in the definition of evacuation routes, identification of shelters and emergency operations centers, in addition to the creation and management of warning systems,

and the development of meteorological and hydrological models used in the forecast. In response actions, with a GIS it is possible to manage the most problematic situations efficiently and quickly, such as actions to combat accidents (contain adverse effects) and to help affected populations (search and rescue). In reconstruction, geotechnologies are also widely used in carrying out the inventory, assessing damage, and identifying safe areas for relocation and reconstruction of affected communities. […] This information is later inserted in a database to be used again in the risk prevention and preparation phase and environmental management.

Although the application of GIS has expanded to several areas of knowledge, mainly in carrying out analyzes on environmental and urban planning in cities, interactions with this type of system are not yet accessible to everyone. Often its use is restricted to technical or academic professionals who already have some affinity with the tool. However, the emergence of the internet and the growing panorama of making cartographic bases available on the world wide web (World Wide Web) introduced a change in perspective, allowing ordinary users, with restricted or little knowledge on the subject, to also have access to the generated products for the functions of storage, analysis, manipulation, and management of geospatial data, using free software. In this context, the emergence, at the end of the 1990s, of Web GIS, a geotechnology that uses the internet as the main means of accessing geoinformation, stands out (Lacruz & Sousa Filho, 2009).

Web GIS combines two powerful technologies when it comes to communication and disaster risk management: GIS, which allows you to integrate, store, edit, analyze, share and present geographic data, and the internet, which provides connectivity at a global level. This interaction results in greater ease in finding and sharing data and tools among users, in addition to being accessible to a greater number of people. Another strength is how risk scenarios, infrastructure, and individuals at risk and vulnerability and risk analyzes are integrated into an accessible platform through which local actors, especially the vulnerable, can share and debate and understand natural risk (Frigerio & Van Westen, 2010). However, several authors claim that they are specialized tools and, therefore, the public is not familiar with how to use them (Albano, Sole & Adamowski, 2015).

Other key advantages are interactivity, dynamics, spatial reasoning, and the ability to flexibly visualize scale and perspective (Le Cozannet et al., 2014). By providing a visual image of the consequences of floods through maps and graphic symbols, Web GIS can improve people's knowledge about the risk of floods, making them more capable of an adequate response (Kjellgren, 2013). However, the content and design of many softwares are not adjusted to the needs of citizens and, therefore, the ability to raise awareness is limited (Kjellgren, 2013). The Lav@hazard tool, for example, is focused on the development of services for the integration of heterogeneous remote sensing data and has proved to be useful for quickly assessing threats from volcanoes and disseminating this information to local actors, especially those that can be affected, and to support those responsible for civil defense and protection planning when choosing appropriate prevention and mitigation strategies (Vicari et al., 2011). READY Web GIS allows you to quickly explore and visualize a complex risk database and past flood scenarios or calamitous events (Albano, Sole &

Adamowski, 2015). Thus, it provides operational support for a regular and continuous information campaign that is more efficient than specific campaigns (O'Sullivan et al., 2012), which are usually carried out on TV and radio.

Therefore, GIS applications in disaster risk management have demonstrated the efficiency in the operationalization of processes for the acquisition, structuring, editing, analysis, and sharing of geographic data concerning the areas affected or that represent disaster risk (Ferreira, 2012). In addition, it has the potential to increase local stakeholders' preparedness for an event to occur (Pinheiro et al., 2021), support local-based methods to increase citizen participation, encourage active involvement, and their ability to adopt protective measures.

RISK AND DISASTERS MANAGEMENT IN THE PROTECTION AND CIVIL DEFENSE OF CURITIBA

One of the main challenges in the management of risks and disasters is related to the uncertainties related to the spatio-temporal aspects with which disasters happen, that is, when, where, and with what intensity. Often, due to insufficient technical staff and available technological resources, local management has limited capacity to act in the face of a disaster (Pinheiro et al. 2021). Similarly, the pace of urban expansion in cities requires that information regarding the vulnerability of physical and/or human elements be constantly updated. Therefore, it is not enough that the means used for recording and/or managing disaster events promotes the collection, organization, and presentation of data. With the obtaining of information more and more numerous and diversified (texts, figures, tables, etc.), this medium must provide conditions for integrated management of risk and disaster information, in addition to decentralized operations of visualization, analysis, and theme research (Fonseca; Garcias, 2020, 2021).

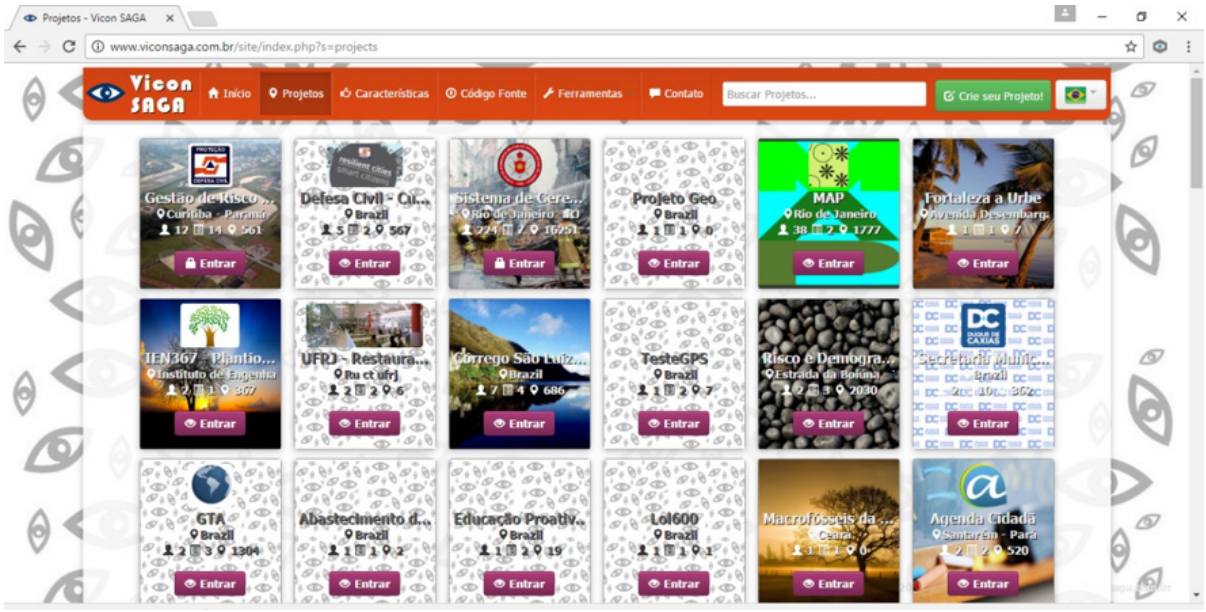
Despite being created in 1985, COMPDEC de Curitiba only drafted the first version of the Municipal Civil Defense Plan between 2001 and 2004. Although the agency has a computer, information, and communication technology, disaster risk management in Curitiba is not yet fully exercised. Most of the records collected by the city's Civil Protection and Defense are dispersed in different bases and formats. Even when there are bases that support the spatialization and centralization of information - as is the case of the Computerized Civil Defense System (SISDC), the requirement for technical knowledge to use and maintain data on this type of platform creates difficulties for technicians related to the creation, maintenance, and integration of these records.

THEORETICAL MODEL FOR THE USE OF VICON WEB GIS IN THE PROTECTION AND CIVIL DEFENSE OF CURITIBA

To develop prevention, mitigation, preparation, response, and reconstruction strategies - included in the macro processes of local disaster risk management in the Civil

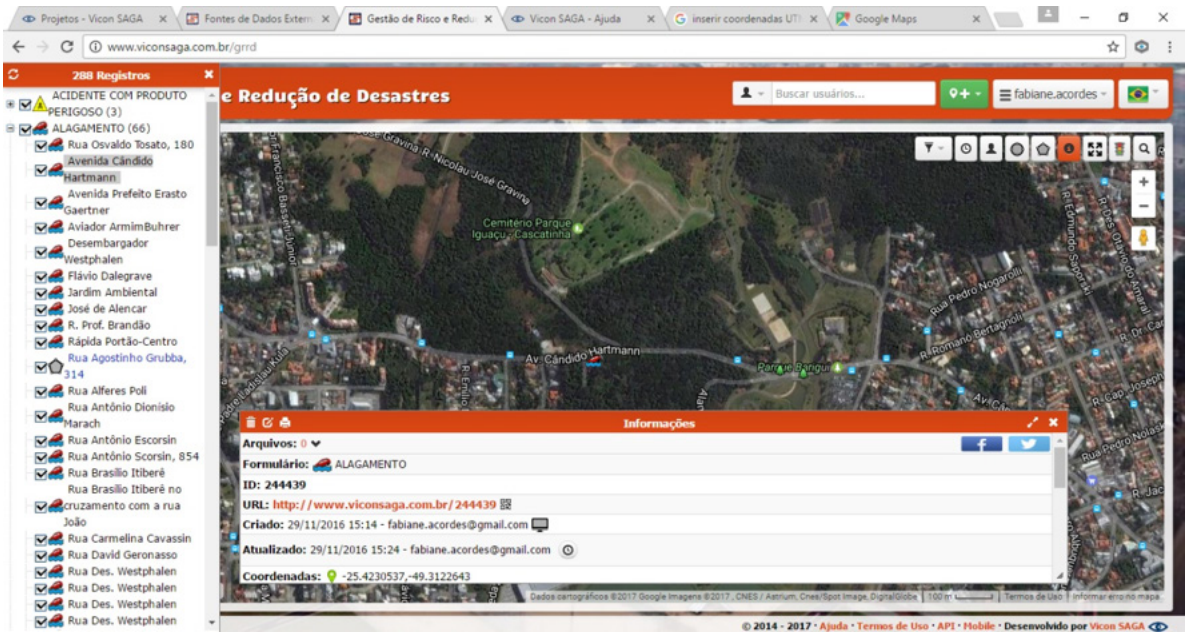
Protection and Defense of Curitiba - a theoretical model is suggested for using the VICON Web GIS platform (Surveillance and Control) of the Geo-Environmental Analysis System (SAGA) package developed by the Geoprocessing Laboratory of the Federal University of Rio de Janeiro, available at https://www.viconsaga.com.br/site/home (Fig. 1).

Figure 1: VICON Web GIS home page showing the projects contained in the platform.



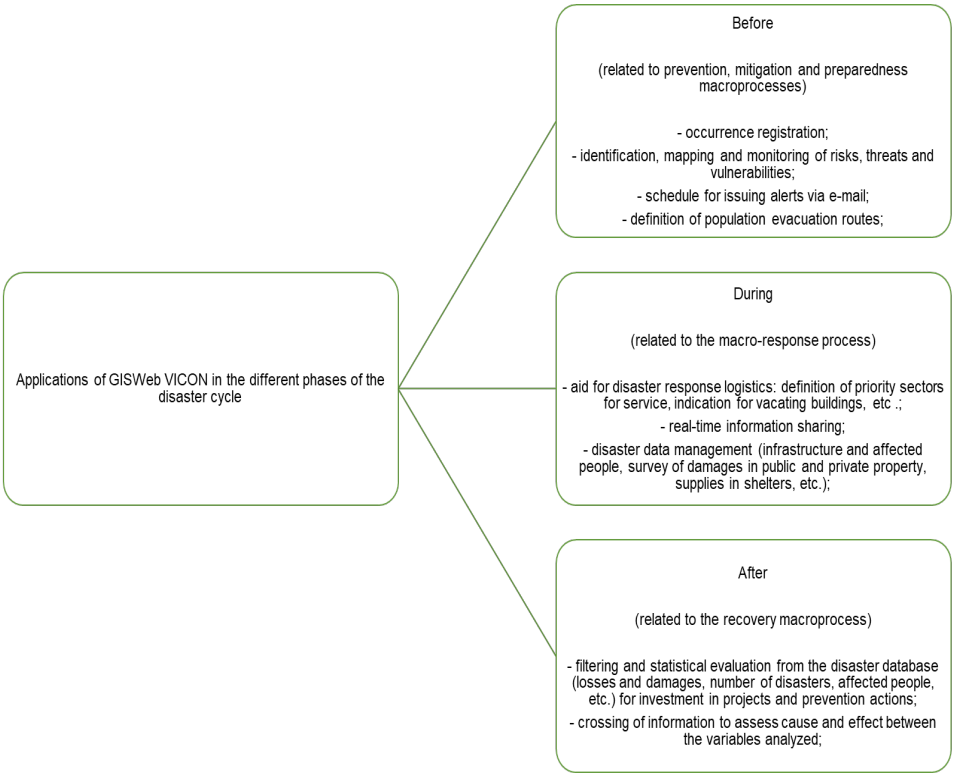
It is a free web platform and global in scope, since it operates through a browser, regardless of the existence of an operating system, and that uses Google Maps as a database (Da Silva, 2009). In addition, VICON includes a security scheme, with password policies and user permission levels (Fig. 2).

Figure 2: Example of the registration view in VICON.



One of the main strengths of Web GIS is that in addition to portraying any events and elements of an environment in a geo-referenced database, VICON offers users a flexible platform for form preparation, data management, and insertion of multimedia content. Also, how risk, vulnerability, and risk analysis scenarios are integrated into an accessible platform through which laypeople can share and understand issues of natural risks or triggered by human action. For this reason, VICON is customizable to any workgroup. In addition, to support disaster risk management uses of the platform by other institutions include registration and spatial analysis of data in the areas of health, education, and the environment. VICON, in addition to exposing the record of disasters and vulnerabilities indicated in the field, based on the organization of a personalized and updated database, allows actions to monitor and control risk situations. Thus, it can be applied in all management stages: before, during, and after the occurrence of a disaster (Fig. 3).

Figure 3: Possible applications for different phases of disasters using VICON Web GIS.



In the previous step, the occurrence of an extensive volume of data related to disasters that have already occurred can be registered. This is an essential part of the management process, considering that the construction of a spatialized database offers autonomy to the local manager so that activities related to prevention are taken based on the knowledge generated from the registered information. It is also important to emphasize that the presence of this data in a unified bank facilitates the retrieval of information, its storage, and sending to users simultaneously through local networks or via the web.

As important as producing a history of the occurrences of disasters, it is the production of the diagnosis of the elements of vulnerability, as well as the execution of the mapping of risk areas for the different threats present in the context of the city (De Lima et al. 2021). It is essential that the surveys are carried out during the normal period, or before a disaster occurs. This diagnosis can be carried out using the tools available at VICON and is facilitated by the extensive range of data formats (.shp, .csv, .kmz, .doc, .jpeg, etc.) that the system allows to import and/or export. Another VICON feature in this phase is the issuance of alerts, which can be programmed or not, sent via email to a project's user group. The alert can be triggered when a certain variable, such as millimeters of rain, reaches a level defined as critical for a given region.

Although the macro-processes of prevention, mitigation, and preparation are related to the actions taken before a disaster, it is in the response stage, which occurs during the event, that the application of GIS systems is quite evident in the management of the disaster. The first and main objective in disaster management, when it occurs, is to identify, at least in the first 72 hours, the most affected areas, and their possible accesses. VICON allows you to cross multiple data and generate different types of maps, which can be shared with users who will help in the field (Noli; Ferentz; Garcias, 2020), allowing a quick analysis of the situation.

Finally, after the disaster has occurred, or during the recovery and reconstruction phase, VICON allows the user, through the application of filters, to establish cause and effect relationships based on the registered information on risk, vulnerability, and occurrences. With these statistics, it is possible to base projects to raise funds for prevention (Pinheiro; Ferentz; Fonseca, 2020), define specific strategies to face these events in the medium and long term, and propose organizational routines for monitoring areas subject to disasters

CONCLUSION

Considering that disasters are characterized by the high damage caused by societies, the use of a Web GIS platform has the potential to assist managers in the processes of acquiring and disseminating information about risks, threats, and disasters. It can also assist administration and Civil Defense and Protection technicians to carry out their work more efficiently and quickly, in addition to allowing these users to share and reuse resources, reducing the institutional and operational fragility of the agency. However, these actors must undergo training, to understand each functionality of the system.

The theoretical model proposed for the Protection and Civil Defense of Curitiba, from the insertion and structuring of data in web VICON, explained the practicality that the platform offers to users in the stages of analysis, monitoring, and diagnosis of processes in disaster risk management. The flexibility to insert forms, update information, cross-check and share data promotes the optimization of time and reliability in decision making. The tool, which is a national initiative and free of cost, can, constitutes a communication tool that makes it possible to improve the knowledge of the recipients, facilitating the informed

debate and increasing the capacity for personal protection, as well as providing a common visual basis for bidirectional communication about the risk situation.

Ultimately, it has the potential to decrease the vulnerability of certain social groups, especially the most vulnerable, and to increase preparedness for a flood to occur, that is, people's ability to take measures to protect their lives, family, and property and, therefore, decrease the number of fatalities, damages, and losses caused to the population in a disaster situation, making them, therefore, more resilient

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