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Asymmetries in the application of Unmanned Aerial Vehicles in different phases of Disaster Risk Management (DRM)

Assimetrias na aplicação dos Veículos Aéreos Não Tripulados nas diferentes fases da Gestão de Risco de Desastres (GRD)

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ABSTRACT: This article aims to highlight the knowledge gaps identified in the use of Unmanned Aerial Vehicles in the different phases of Disaster Risk Management (DRM). To this end, a bibliographic review of 254 articles reporting on UAVs and natural disasters in the period 2000-2020 is presented. To select a sample of publications that address the relationship between drones and natural disasters, from 2000 to 2020, quantitative searches were made on the Google Scholar. Only the articles published in journals or events were considered for this purpose. The searches were carried out using the following terms: disasters; hazards; risk; natural disasters; UAV; drone. The linguistic variation of the terms was also considered (terms in English, Spanish and Portuguese). As a main finding, it is argued that there are few studies on the use of UAVs in risk mitigation in the pre-disaster phase. To develop this argument, the article begins with a discussion of the structure of DRM, then addresses the use of drones in natural disasters, and finally develops a critique of the asymmetry that exists in the use of UAVs in DRM.

Keywords: disaster risk management; disaster risk reduction; UAV; drones.

RESUMO: Este artigo tem como objetivo destacar as lacunas de conhecimento identificadas na utilização de Veículos Aéreos Não Tripulados nas diferentes fases da Gestão do Risco de Desastres (GRD). Para isso, é apresentada uma revisão bibliográfica com 254 artigos relatando os VANTs e desastres naturais no período de 2000-2020. Para selecionar uma amostra de publicações que abordam a relação entre os drones e os desastres naturais, de 2000 a 2020, foram feitas buscas quantitativas no Google Acadêmico. Apenas os artigos publicados em periódicos ou eventos foram considerados para este fim. As buscas foram realizadas com os seguintes termos: desastres; perigos; risco; desastres naturais; UAV; drone. A variação linguística dos termos também foi considerada (termos em inglês, espanhol e português). Como principal achado, argumenta-se que existem poucos estudos sobre o uso de VANTs na mitigação de riscos na fase pré-desastre. Para desenvolver esse argumento, o artigo começa com uma discussão sobre a estrutura do GRD, depois aborda o uso de drones em desastres naturais e, finalmente, desenvolve uma crítica à assimetria que existe no uso de UAVs na GRD.

Palavras-chave: gestão de risco de desastres; redução do risco de desastres; UAV; drones.

1. Introduction

In April 2009, a 6.3 magnitude earthquake occurred in the town of L'Aquila (central area of Italy), causing 309 deaths, and over 1,600 injuries. In August 2016, another earthquake occurred in central Italy, now in the city of Amatrice, resulting in over 300 deaths. In both cases, more than 50 percent of the respective cities were destroyed. This context highlights the possibility of considering disasters as a severe disturbance in the functioning of a given community, with impacts that exceed its capacity to recover from its own resources (UNISDR, 2009). The use of Unmanned Aerial Vehicles (UAVs) has been widely discussed in the case of L'Aquila (Baiocchi *et al*., 2013; Dominici *et al*., 2016). In Amatrice, UAVs are popular among different news networks as they frequently used this technology to communicate the impacts of the earthquake to the population.

Although the use of UAVs in different fields has only increased in recent decades, the society has been using unmanned aircrafts since 1800s. According to Kim and Davidson (2015), the first records of the use of unmanned aerial vehicles were made in the military area, when in 1849 the Austrians launched 200 unmanned balloons to bombard the city of Venice. A few years later, in 1860, unmanned balloons were used for bombing in the US Civil War (Tremayne & Clark, 2014). Historically, the development of UAV technology has been driven by its applications and needs in the military, and later it converted to civilian applications (Fahlstrom & Gleason, 2012; Kreps, 2016). Among the main civil applications, we highlight the: remote sensing (Colomina & Molina, 2014), vegetation monitoring (Ahmed *et al*., 2017) and agriculture (Urbahs & Jonaite, 2013).

Regarding Disaster Risk Management (DRM), UAVs are already being used worldwide to provide vital information, including search and rescue, transport of medicines, real-time imagery of damaged infrastructure and in the restoration of the communication networks (Kim & Davidson, 2015). Currently, the main factors that highlight the use of UAVs in the DRM are:

1) being able to operate quickly after an event;

2) flying in conditions that manned aircrafts would not be able to;

3) transporting resources to the areas of difficult access;

4) operating at a fraction of the cost of manned aircrafts;

5) generating scenarios in three dimensions before and after a disaster.

In view of these aspects, the objective of this study is identify gaps in knowledge between unmanned aerial vehicles and Disaster Risk Management (DRM). For this purpose, this study presents a vast bibliographic review that includes more than 254 scientific studies, covering a period of 20 years (2000/2020), related to UAVs and Disasters, which allows understanding the main gaps and potentials in the development of the UAVs for DRM.

2. Disaster risk management

The origin of the recent impact studies of the explosion of the two vessels in Halifax, Canada, in 1917 (Prince, 1920; Scanlon, 1988; Perry & Quarantelli, 2005). However, the concept of Disaster Risk Management (DRM) emerged only in the 1990s (Narváez *et al*., 2009; Arce & Córdoba, 2012). It is possible to define DRM as "a systematic process of using administrative guidelines, organizations, skills and operational capabilities to implement policies and strengthen response capacities to reduce the adverse impact of natural hazards and the possibility of a disaster" (UNISDR, 2009, p. 10). This definition highlights the broad characteristic of the term DRM, which encompasses both Disaster Risk Reduction (DRR) and Disaster Management (DM) (Baas *et al*., 2008).

The probability that a natural event (whether caused by human action) will result in certain impacts on society is understood as a risk. On the other hand, the way a society is exposed to such risks determines its vulnerability in the face of the possibility of a erupting. While vulnerability is a variable linked to the social aspects. Risk, on the other hand, is a variable linked to the physical events (UNISDR, 2009).

Throughout history, humanity has attributed different causes to the occurrences of different disasters. The available literature, groups these different understandings into three main paradigms:

1) pre-science paradigm: disasters as a result of divine actions (Gaillard & Texier, 2010);
2) refuted paradigm: disasters as an exclusive result of natural events;
3) current paradigm: disasters as a result of social and natural interactions, this paradigm has internalized in society the responsibility for generating the vulnerability conditions necessary for the occurrence and intensification of disasters (Gilbert, 1995; Mattedi & Butzke, 2001; Chester, 2005; Arce & Cordoba, 2012, Perry, 2018).

Throughout the history of the social construction of these three paradigms, different terms have been used to understand the relationship between social and natural in disasters research (Chmutina & Meding, 2019; Staupe-Delgado, 2019). According to Davis (2019, p. 13), "The words used to describe plans or processes are always good indicators of changing attitudes and approaches.". The transformation of terms, and the dilemmas that represent them, are presented here to introduce readers who are not from the field of disasters (such as researchers in the UAV technology field). To understand how UAVs are used and studied in natural disasters, it is sufficient to have a clear understanding that disasters are social events with natural triggers.

Recognizing the importance of risk and vulnerability in reducing the impacts of disasters, the UN launched the International Decade for Natural

Disaster Reduction (IDNDR) in 1990, which was followed by those of Yokohama (in 1994), Hyogo (in 2005) and Sendai in 2015. These agreements reinforced the idea of vulnerability and the importance of mitigating disaster risks rather than just countering their effects. This has led to a transformation in the fight against disasters, moving from the idea of Disaster Management (Yokohama) to the concept of Disaster Risk Management (Sendai). More precisely, these frameworks lay the foundation for the post-2015 strategy for disaster risk reduction. While the Hyogo Framework focused on disaster management planning, the Sendai Framework promotes a paradigm shift, focusing on disaster risk management planning.

The DRM aims to formulate policies, instruments and strategies that may lead to the reduction and control of the disaster risk (Narváez *et al*., 2009; Arce & Córdoba, 2012). For this to occur, it is essential to broaden the perception of disaster risk to identify them before, during and after a disaster. In a complementary way, it is necessary to mitigate the identified risks so that, finally, managing the disaster can become possible (which includes a response to the events and a better reconstruction of the affected areas). Preventing and mitigating risks, preparing for and responding to disasters, and finally rebuilding and rehabilitating impacted areas correspond to the 3 phases of the cyclical DRM model (Figure 1).

By designing disaster risk management in well-defined phases, DRM models reduce the complexity of disasters. According to Kelly (1998), models can:

1) simplify complex events;

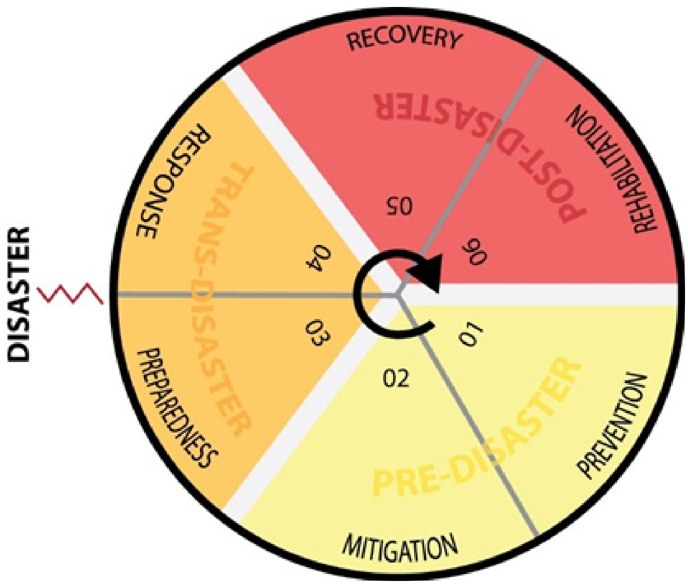

FIGURE 1 – Phases of the cyclical model of Disaster Risk Management (DRM).
SOURCE: Elaborated by the authors.

2) make it possible to compare the actual situation with a theoretical model;

3) make it possible to quantify disaster events;

4) establish a common basis of understanding for all individuals involved (Kelly, 1998; Asghar *et al*., 2006).

Circular DRM models enable understanding of the post-disaster phases (Time 02, response, and reconstruction) and link them to the pre-disaster phases (Time 01, mitigation, and preparedness). The importance of considering DRM as a cyclical model, with a direct relationship between pre- and post-impact phases can be evidenced in the Sendai Protocol (2015-2030), which stresses the importance of Building Better (BBB) to reduce disaster risk (UN, 2015).

Due to the cyclical nature of DRM, there is no way to talk about disaster risk management without the information and knowledge about the relationship that exists between urban development and disasters. Proper management of information flow is the key to successful DRM (Asimakopoulou & Bessis, 2010). In this regard, it is essential to understand that the larger the disaster event, the greater the amount of the information that must be collected, processed, and disseminated.

3. UAV in the management of risk disasters

For the use of UAVs to occur in order to enhance management, it is necessary to elaborate the protocols for use, both to obtain information about the urban dynamics in the pre-disaster period and to obtain the information during and after disasters. People involved in urban planning and disaster risk management should clearly keep in mind how the UAVs operate at different times in disaster management. The main issues that must be addressed when discussing such UAV protocols include regulations, security, and privacy concerns (Kim & Davidson, 2015). The problem of lack of protocol for UAV use in the management sector should be manifested by considering two scenarios:

1) when there is little or no regulation, and;

2) when there is over-regulation. In the case of the US, over-regulation makes it difficult to use UAVs in the response phases (ARC, 2015).

In case of Nepal, after the 2015 earthquake, the government banned the use of UAVs due to the government's concern that the images could be used for purposes other than the DRM (Hern, 2015).

Since 1970, robots have been used in support of disaster response. The use of drones is linked to the type of sensor or data that the UAVs can generate, which gave origin to the notion of sensor drones (Kaufmann, 2016). The nuclear collapse on Three Mile Island in 1979 may exemplify the importance of increasing the use of UAVs equipped with different sensors. In this case, UAVs were sent to capture the radiation level of the region to avoid sending people into the impacted areas (ARC, 2015). In recent years, UAVs have been intensively used in various types of disasters, such as the nuclear disaster that occurred in Japan in 2011. In that case, the UAVs mapped the radiation and impact in Fukushima, which prevented people from being sent to the hazardous areas (Adams *et al*., 2014). Another relevant case in the use of UAVs happened in the largest environmental disaster in Brazil: the collapse of ore dams in the city of Mariana /MG in 2015. In this case, UAVs were used for the recognition of the impacted area and the preliminary analysis of the extent of damage.

UAVs can be classified through five distinct aspects (Dalamagkidis, 2015; Kim & Davidson, 2015):

1) driver: civilian or military;

2) type of flight: depending on the type of flight, they are made in different designs, such as multi-role, fixed wing, balloon, or fan technology;

3) size: there are UAVs with lengths ranging from less than 1cm (cost $100) to over 80 feet long (military UAVs);

4) payload: they can have built-in cameras and sensors (Lidar, infrared, weather sensors), and different payload capacities;

5) level of automation: in addition to remote control functionality with a radio remote control or a handheld device such as a laptop, tablet or smartphone, the operator can input a flight path, so the UAVs can operate autonomously or semi--autonomously.

These aspects can alter the function of UAVs in DRM, as they determine the flight time, the amount of information to collect, and the phases of management at which it can be the most effective (Iqbal *et al*., 2015; Kim & Davidson, 2015).

While multirotor UAVs are most effective for hovering near buildings or victims to provide the detailed damage assessments, fixed-wing UAVs are the most effective in the pre-disaster period to capture the information about urban dynamics in large urban areas (Putro *et al.*, 2021). This functionality of a UAV is notable since this type of technology consumes less energy in flight and can fly over wide areas (Iqbal *et al*., 2015). Multirotor UAVs are more effective at the micro impact scale, while fixed-wing UAVs are more effective at the macro impact scale. That is, depending on the affected region, the type of disaster, and the management phase, one or more UAVs of different types may be required. Understanding these aspects can be crucial for the operationalization of UAVs in DRM.

Therefore, it is possible to understand UAVs as a type of multipurpose technology for DRM. This is because they can be used to: collect information (in all stages of management), establish communication in the disaster situation (when communication infrastructure is damaged), and transport resources to the impacted areas.

From the subdivision of management into three periods (before, during and after disasters), and the consideration of the four main factors that differentiate the application of UAVs in DRM (type of disaster, impact, scale and regulation), it is possible to understand and structure how UAVs can work in different phases of management. This panorama allows subsidizing the elaboration of protocols for the use of UVAs, which consider the laws and peculiarities of each region, as well as concerns about security, privacy and integrity of information. The perception of UVAs operating along the disaster cycle allows, therefore, to consolidate this emerging technology as an effective tool in terms of risk management.

The implementation of UAVs in the pre-disaster period aims to promote the monitoring of urban dynamics that produce vulnerability, in order to enable risk prevention and mitigation. The relevance of this technology before a disaster occurs, despite being little explored, is significantly important. Strategic and operational planning for risk assessment in the pre-disaster period can be enhanced by using UAVs to provide the aerial images of the infrastructure and buildings in a vulnerable region (Restas, 2015). In addition, the information provided by UAVs can support urban planning with the enrichment of Geographic Information Systems (GIS) databases by providing high spatial and temporal resolution spatial information. These features contribute significantly to the understanding of the complexity of the scenario in the pre-disaster period. The type of UAV with the greatest potential contribution to this phase are fixed-wings, since they can fly over and map larger areas with greater autonomy.

In the scenario of a disaster, the first few hours are crucial. In addition, it is in the first few hours that the available resources are the scarce, which makes it difficult to assess and respond to impacts. The time pressure and the urgent need of information highlights the potential for the use of UAVs during disasters (Câmara, 2014; Bogue, 2016). Since UAVs can be operational within minutes, while manned aircraft can take hours to do so (Kim & Davidson, 2015). A report published by the "Red Cross" highlights four main uses of UAVs, in the response phase, in 22 disasters from 2005 to 2015:

1) surveys;
2) reconnaissance and mapping (68% of disasters);
3) structural inspection (48% of disasters);
4) debris estimation (ARC, 2015).

On the one hand, however, are the advantages of using the UAVs, on the other are the issues of privacy of the information obtained and the regu-

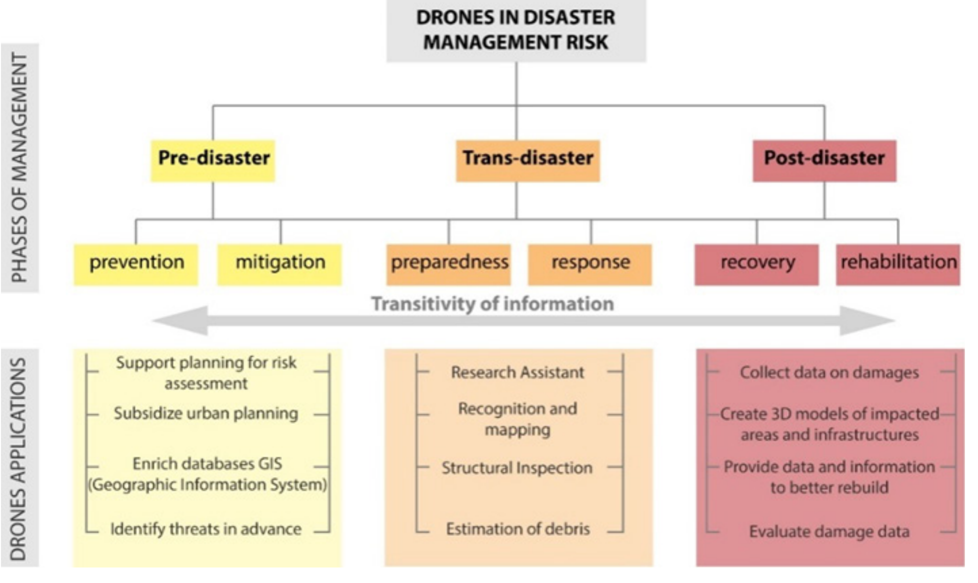

FIGURE 2 – Application of the UAVs in the DRM phases.
SOURCE: Elaborated by the authors.

latory problems that can characterize the problems associated with using UAVs during disasters.

In the post-disaster period, the use of UAVs enables intelligent reconstruction of infrastructure, which allows for better recovery and reconstruction of impacted areas (Erdelj & Natalizio, 2016). Actions during this period are often performed with imagery acquired through ground platforms, satellites, and conventional aerial imagery with manned aircraft. Although these technologies can also cover large geographical areas, their use is limited for any detailed investigations as there are limitations in spatial and temporal resolution. UAVs have great potential to collect data for post-disaster actions, as they can provide high spatial resolution imagery more often than conventional means (Chou *et al*., 2010; Quaritsch *et al*., 2010; Mukherjee *et al*., 2014). In addition, UAVs, through Lidar sensors or photogrammetry techniques, allows creating three-dimensional models of the impacted areas that need to be recovered and reconstructed (Yamazaki *et al*., 2015; Tanzi *et al*., 2016). The application of UAVs in all phases of DRM can be seen in Figure 2.

To maximize the contribution of UAVs to DRM, it is necessary to consider the DRM framework. That is, consider how different types of UAVs can be used in the different phases of management to meet the demands of the region, scale, and impact of the disaster on individuals. The information structure of the DRM is another important factor in making UAVs more effective in management, since the type and degree of information varies according to the organizational structure. Consequently, it should be considered that information produced in one phase can be used in the other phases (information transitivity). This requirement makes it necessary to develop specific devices from which it is possible to collect, organize, integrate and disseminate the information collected by UAVs, not only in the post-disaster period but in all the stages of the disaster.

Although UAVs are being used to tackle disasters all over the world, they can mainly benefit the so-called "underdeveloped" countries, since the operating costs of this technology can be as much as 180 times lower compared to the costs of using regular airplanes and helicopters. More precisely, while the estimated hourly cost for a manned aircraft is $ 250 to $ 600, the cost per hour to operate a UAV is approximately $ 3 (Kim & Davidson, 2015). Therefore, access to this type of technology for DRM is not only restricted to developed countries, but can largely favor underdeveloped countries.

4. Asymmetry of UAVS in disasters

The multipurpose nature of UAVs (providing information, maintaining communication, and transporting resources), results in an asymmetry in the use of DRM. To understand this asymmetry in the use of UAVs in Disaster Risk Management, it is also necessary to investigate the variety of uses of UAVs for DRM by studying the different individuals involved (rescue workers, managers, and volunteers), as well as the use of this technology before, during, and after the disasters. In the light of this complexity, there are several perceptions about the need for and use of UAVs in different situations and phases of DRM. In this scenario, the use of a UAV in DRM depends on both:

1) who is using this technology and;

2) which of the management phases a UAV is being used. In this sense, there is an asymmetric structural character in the use of UAVs, inherent to the complexity of disasters and the multi-purpose characteristic of the technology.

To identify how UAVs are used in management, a literature review was conducted (Figure 03). Through this review it is possible to note, on the one hand, the intensification of studies on the application of this technology in DRM over the years and, on the other hand, in which periods of management UAVs are most used for research. Asymmetry that occurs in the application of UAVs in disaster management can also be explained by Guy Debord's idea of a society as a spectacle. That is, news about disasters and the impacts caused by disasters generate more commotion than news about disaster risk prevention and mitigation. In the political arena, it translates into more investment and interest in post-disaster solutions. As a result, UAVs are more often used to assess the damage of

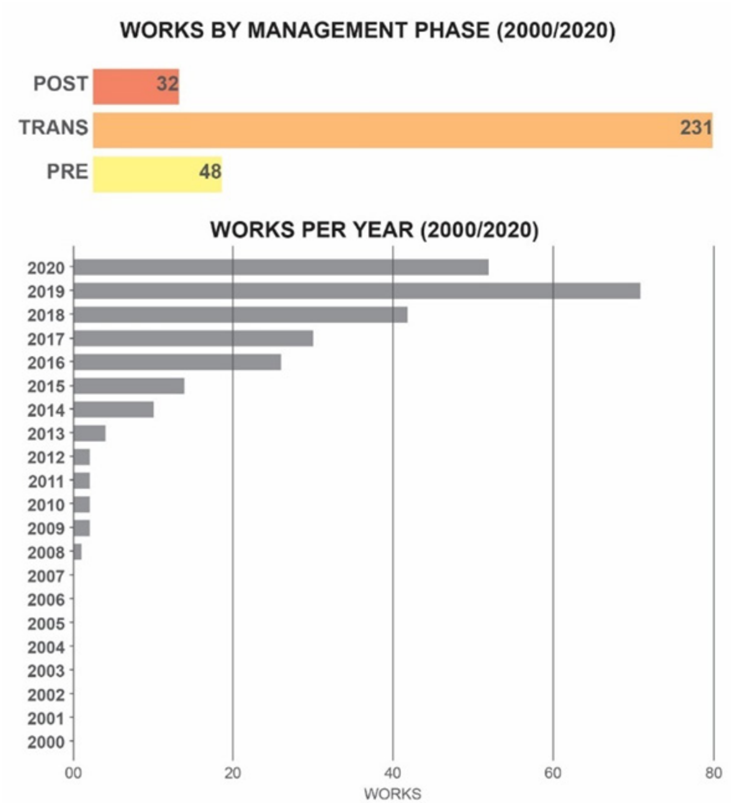

FIGURE 3 – 254 Works that investigate the relationship between UAVs and disasters triggered by natural hazards (2000/2020).
SOURCE: Elaborated by the authors.

the disaster than to assess the production of vulnerability in the urban environment.

To select a sample of publications addressing the relationship between drones and natural disasters from 2000 to 2020, quantitative Google Scholar searches were conducted. Only articles published in journals or events were considered for this purpose. The searches were conducted using the following terms: disasters; hazards; risk; natural disasters; UAV; drone. Linguistic variations in the terms (English, Spanish, and Portuguese terms) were also considered. From the results obtained, only articles that could be fully accessed and that had these search terms in their title, abstract or in their keywords were considered. Subsequently, a qualitative analysis of each of the 254 selected articles was carried out. The qualitative analysis allows us to identify how the different studies addressed the relationship between UAVs and disasters, and how they found that this relationship occurring before, during, and after disasters. The classification of articles, by year and phase of disaster management, resulted in figure 03. Although rare, a few studies were identified that addressed the use of UAVs in one or more phases of DRM.

The literature review included 254 scientific publications that specifically address the relationship between UAVs and disasters caused by natural events. In this sense, to maintain the focus of the objective, the use of drones in humanitarian issues was not considered, so as not to lose the focus of the objective (having to expand to issues involving armed and political conflicts). Disasters in the context of war may not be related to triggering natural disasters, which is why they were not considered.

Among the main investigations on the use of drones in the trans and post- disaster period is the use of drones to locate the victims and to re-establish communication networks. Among the pre-disaster investigations, one can highlight the use of UAVs in mapping, mainly to identify potentially dangerous fire outbreaks. This research revealed previously unknown information about the use of this technology in disasters caused by natural hazards, including:

1) 90% of the studies analyze the potential use and alternatives of this technology in a disaster response phase;

2) there is no consensus, or a consolidated protocol of use, across the 254 scientific studies investigated, on how to systematically operate UAVs in DRM;

3) only 18% of studies investigate the use of UAVs to mitigate risks in the pre-disaster phase;

4) 96% of studies were published from 2014 onwards, confirming the emergence of this technology in Disaster Risk Management (DRM).

Thus, despite the different success cases in the use of UAVs in specific disaster situations, the potential contribution of UAVs in the case of DRM is fragmented and still underutilized, especially when it comes to the pre-disaster phase. It is important to emphasize that this is not a search for a simple symmetry in the use of drones in disasters. To improve the use of drones in disasters, it is critical to establish an understanding of existing and underexplored knowledge gaps. This asymmetry in the use of drones in disasters indicates the importance of seeking new knowledge and advances in the use of drones in the pre-disaster phase.

As a result, it turns out that the scientific community produces a lot of knowledge to apply UAVs in the disaster response phase, but produces little knowledge to use UAVs as tools to better understand the physical space in which disasters occur and mitigate them from a social point of view. It is time to use this technology to help reduce vulnerability as well, not just use it for any emergency responses. In order to address the urban nature of disasters, an understanding of the urban space in which disasters occur is essentially required. This understanding involves analyzing the urban dynamics that produce and amplify vulnerability. The exclusive use of UAVs in the post-disaster period cannot solve the disaster problem, but underutilizes the technological potential of this technology and sells a false image of safety (or false efficient response) to respond to a disaster. The literature review conducted allowed the outline of this problem. In this context, it is crucial to understand that the development of UAVs is closely aligned with the knowledge produced by the major international disaster risk documents (Yokohama, Hyogo, and Sendai), which can greatly help to incorporate important technological developments in the UAVs to smartly identify the production of the vulnerability in the pre-disaster phase.

When considering the 254 articles analyzed, it is noticed that while there are many studies on the types of applications that UAVs have in the disaster management framework, there are only a few studies that investigate or propose devices to operationalize UAVs information in disasters. More precisely, simply determining how to use UAVs for rescue or risk mitigation does not prevent the intensification of the information flow problem (conflicting, volatile, incomplete, excessive, and incorrect information), for the DRM. For the use of this technology to contribute to the correct information, it is essential to develop some organizational structures for the use of drones in order to solve the problem of information flow and communication during all stages of DRM.

5. Conclusions

The development of UAVs technology for disaster risk management needs to be monitored and supported at all stages of DRM. There is a clear need to integrate the rules and regulations for the use of UAVs with disaster risk management actions and strategies to avoid the excessive or lack of legislation, which compromises the use of this technology in the management. The proliferation of UAVs, especially low-cost UAVs, will soon enable random individuals and small local organizations to quickly capture, process and share aerial imagery and disaster data. This, in principle, should be interpreted with caution. As, in the pre-disaster phase, only certain individuals will have an interest in using UAVs to capture risk production, in contrast, during and after disasters, the UAV data from DRM individuals will be competing with hundreds of UAVs from various random individuals.

In this sense, the new organizational structures must understand the collection, production and sharing of information without diverting it to purposes other than DRM. In other words, the data and information collected by different individuals should be properly recorded and stored, thus preserving the necessary security and privacy measures and making it possible to maintain the integrity of the information. If, on the one hand, we must analyze how the integration and sharing of this high volume of information will occur without intensifying major gaps in information flows, on the other hand, it is necessary to plan the physical division of the airspace occupied by the different individuals using the UAVs during disasters, so that they can act in close proximity (and cooperation) without presenting a risk of collision between different equipment. At the same time, it is important to create platforms that identify the areas already mapped in certain periods, to avoid the production of unnecessary information and the intensification of airspace occupation.

The main contribution of this text is the criticism that points to the use of drones mainly after the outbreak of a disaster and not before. It is a criticism about a prevailing vicious cycle: the more it is used after a disaster, the more the technology is developed to perform in the post-disaster phase. The analysis of the 254 scientific articles allowed us to identify the inherent flaw in using drones to solve a disaster problem (acting only at the tip of the problem, i.e., using drones when the disaster has already occurred). In this scenario, it was found that the scientific community produces much knowledge to use UAVs during and after disasters, but produces little knowledge to use them as tools that could help better understand the physical space in which disasters usually occur. As a result, this technology is underutilized to mitigate disasters from a social point of view. It is therefore safe to say that the use of UAVs to reduce vulnerability production is an exploratory research topic.

To address the urban nature of disasters, it is necessary to understand the urban space in which the disasters occur. This understanding involves analyzing the social aspects that produce urban vulnerability. Despite the valuable and unquestionable contribution that UAVs offer to the trans and post-disaster phases, their application should not be restricted to certain management periods. The intensive use of UAVs during and after disasters sells a false image of safety, or a false efficient solution, in the face of real problems consisting in reducing social exposure to risks. Finally, we sought to demarcate this problem, to indicate the gaps and possibilities for developing new studies for future applications of UAVs focused on DRM.

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