THE INFORMATION AND COMMUNICATION TECHNOLOGIES IN THE RISK MANAGEMENT OF SOCIAL AND ENVIRONMENTAL DISASTERS

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Introduction

The worsening of the impacts of social-environmental disasters has become one of the most challenging issues in the past decades. On the one hand, there is a growing sophistication in the process of formulating and implementing management programs and projects (WORLD BANK, 2010; DAUPHINÉ; PROVITOLO, 2013); on the other hand, one sees the greater vulnerability that is reflected in the progressive increase in the number of affected individuals and economic losses (UNISDR, 2016). The management of social-environmental disasters can be described through the relation between Problem-Solution: the way in which the population and government conceive a disaster delimits their conditions of confrontation. Therefore, one of the decisive aspects of the management process is the question of the quality and effectiveness of risk communication. In this sense, Information and Communication Technologies (ICTs) has been playing a central role in the management of disasters (CROWE, 2012).

Over the last 40 years, the approaches developed around disasters have undergone profound conceptual transformations. It is possible to classify these transformations into two main paradigmatic models: 1) physicalist model - stemming from Earth (Natural) Sciences, with a focus on events and threats of natural origins, this approach argues that disasters are products of natural extreme conditions that impact on the neutral and innocent society (LAVELL, FRANCO, 1996, ARCE, CÓRDOBA, 2012); 2) a model of integral risk management - this model systems from criticisms of the physicalist model developed mainly by the Social Sciences, which inserted a new factor in the debate: vulnerability (HEWITT, 1983; LAVELL, 2000, XAVIER; BARCELLOS; FREITAS, 2014). From these criticisms comes the integral risk management model. This model can impli-

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cate in three guidelines: 1) risk identification; 2) risk reduction; 3) disaster management (LAVELL; FRANCO, 1996; ARCE; CÓRDOBA, 2012).

Disaster Risk Management (DRM) is a concept that emerged in the 1990s as an alternative to the visions of disaster management that prevailed at the time. These visions favored above all the preparation to meet emergencies and disaster situations (NARVAEZ; LAVELL; ORTEGA, 2009; ARCE, CÓRDOBA, 2012). With the emergence of the concept of DRM, management ceases to be a set of actions of physical protection to the disasters, to become a set of actions of prevention and mitigation of the risk of the occurrence of the disasters (LAVELL, FRANCO, 1996; LAVELL, 2001). Based on the integrated risk management model, DRM should be considered as an intrinsic component of sustainable territorial development and development management, in which vulnerability and risk refer to a context characterized by the risk society (BECK, 1992; GUIVANT, 2016).

Risk management therefore refers to a social process whose ultimate goal is the prevention, reduction and permanent control of disaster risk factors. Thus, the DRM encompasses the very management of disasters (which has a focus on the trans and post disaster period), since it considers that response and reconstruction are also important for risk reduction. A comprehensive DRM can be based on five distinct components: 1) prevention; 2) mitigation; 3) preparation; 4) response; 5) recovery (COPPOLA, 2011, ARCE, CÓRDOBA, 2012; UITTO, SHAW, 2016). From these components, the DRM has different scales of intervention, ranging from global to local and community, and the existence of organizational and institutional structures that operate the flow of communication and use of ICTs in these levels of DRM are fundamental (NARVÁEZ; LAVELL; ORTEGA, 2009).

In this context, it is possible to understand ICTs as a process of "technological convergence" (UN, 2002, p. 47), in which the most important part of Communication Technologies (CT) is incorporated by Information Technology (IT). Conventional communication technologies are essentially rigid, since their functions are constant and are frozen in the design of the devices (television, radio, newspaper, telephone). In contrast, the ITs include an aspect of the information on their integration with the computer through open digital connections (web 2.0, Facebook, Twitter, YouTube, Apps). The union of these two technologies is called ICTs, expressed by the formula ICTs = IT + CT (UN, 2002). The ability to obtain and distribute large amounts of information to a large number of people over a short period of time makes it clear that "ICTs play an important role as facilitators of disaster risk management" (UN, 2013, p. 01).

This text aims to address the use of ICTs in DRM models, in order to identify how the different technologies used operate in the different phases. Two aspects highlight the importance of the theme and justify its choice: 1) the importance of communication flows in the DRM; 2) the potential of ICTs to improve or impair communication flows in the DRM. The main method used to develop this research was the bibliographic review on the operationalization of ICTs in the DRM. This review first investigated the different types of management models, as well as the perspective of the Sendai Conference on ICTs, followed by a review on the operationalization of ICTs in the DRM, and finally the use of ICTs in communication flows in the DRM. As a result, the text evidences an asymmetry in the operationalization of these technologies in the DRM, as well as the need to consider the cognitive aspects inherent to the meaning, dimension and direction of the flow of communication of the risks in the application and improvement of the ICTs in the DRM.

Disaster risk management models

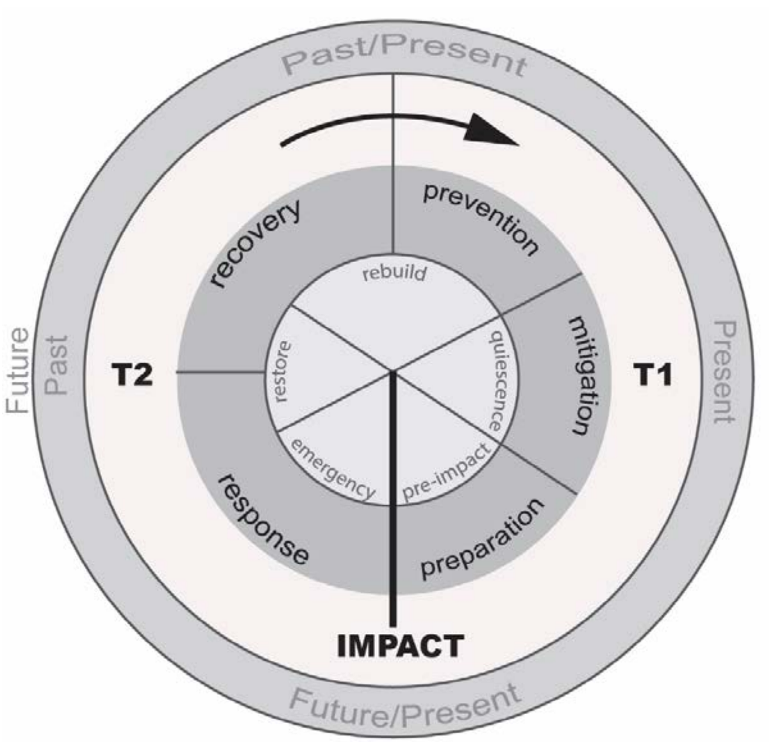
Reducing the impacts of social-environmental disasters involves understanding the complexity of relationships between society and nature. For the reduction of the complexity of disasters to occur, it is necessary to understand how the stages of a disaster are related within the different approaches .This understanding can be enhanced through the use of DRM models, because according to Kelly (1998), models can: 1) simplify complex events; 2) make it possible to compare the real situation with a theoretical model; 3) make it possible to quantify the events of disasters; 4) to establish a common basis of understanding for all actors involved (ASGHAR; ALAHAKOON; CHURILOV, 2006). It is possible to classify disaster management models from the notion of sequence (CARR, 1932) that the steps establish, evidenced by two main categories of temporal interaction models: a) rectilinear: an approach that does not link stages such as processes; b) circular: an approach that allows to understand disasters as processes. Other models, with an understanding of disasters as processes, address the temporal interaction in spiral models, in order to show that the resilience conditions are never equal in the same point of the previous cycle (FORESTI, 2015).

The rectilinear models of DRM are based on the Prigoginian view of temporality, that is, aspire to break the equivalence between before and after in a linear approach of time .The time approach proposed by Prigogine has three foundations (RICE, 2007; CARVALHO, 2015): 1) irreversibility: temporality implies the impossibility of returning to the initial conditions; 2) asymmetry, that is, the difference between past and future, which means a non-repetitive and mechanistic perception of nature; 3) unidirectionality, that is, direction from the past to the future, which results in the use of the term “arrow of time” (GOULD, 1987; RICE, 2007; CARVALHO, 2015). From the notion of time arrow, the misconceptions of rectilinear management models become evident, since they disregard that the same conditions of vulnerability in the past may occur in the future (unidirectionality, irreversibility and asymmetry), as well as the phases of disaster management that occur during the phenomena.

Management models are based on different forms of understanding and representation of time. Thus, if on the one hand the linear time models used by traditional management models were introduced from a notion of linear time of Christianity, on the other hand, the circular models of DRM use a notion of mythical circular time (GOULD, 1987; ALEXANDER, 2000; BARROS, 2013). Therefore, circular models can be considered to be based on non-rectilinear time processes, and instead of dividing the DRM into two phases, these circular models propose 4 or more phases arranged in a circular pattern. This approach allows us to understand disasters as integrated processes, in which the stages that occur in the pre-disaster period (Time 1) influence and are linked to the post-disaster period (Time 2).

This notion of sequence, proposed by the circular models, allows understanding the interfaces that are established between the different management stages (Figure 01). In addition, it admits that the same conditions of vulnerability of the past may be present in the future. That is, these models support the existence of a "continuity principle" in which a greater vulnerability in Time 1 could have a greater impact on Time 2 (OMER, ALON, 1994; MATTEDI; BUTZKE, 2001). When considering that the recovery of an event can lead to the occurrence of other events and that, therefore, disasters tend to exist in a continuous process, the circular approach becomes more relevant to the rectilinear approach. The operationalization of the circular model can be exemplified and contextualized, in the national scenario, through the structuring of Civil Defense of Brazil, which comprises the stages as "a continuous, integrated, permanent and interdependent process" (MIN; SEDEC; DPP, 2017; p. 22).

Figure 01: Circular DRM models and stages interfaces.

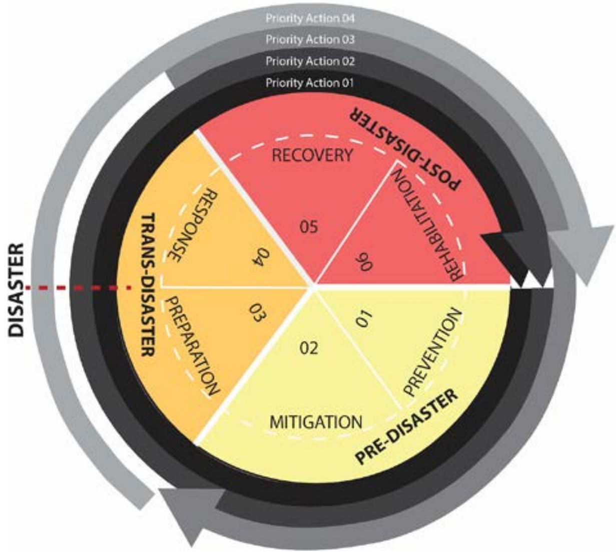


Source: Adapted from Alexander (2000) and Coppola (2011).

In the last 10 years, DRM models have been guided by the principles adopted by the Hyogo Framework for Action (2005-2015). During this period, there was an acceleration in the formulation and implementation of models that focus only on the natural aspects of social-environmental disasters. These measures are often complemented with several actions, which include awareness campaigns, risk assessments and early warning systems. At national, regional and local levels, most countries have developed legislation, policies, programs and projects to address the growing threat of disasters for humanity. However, these initiatives have been uneven (BRICENO, 2015). Despite the efforts of the Hyogo Conference, DRM still focuses on the response and reconstruction phases, failing to effectively address the vulnerability reduction, which is the main component through which risks can be mitigated.

It is possible to understand the impasses of disaster risk management through the subsidies established by the Sendai Framework. After all, the main guidelines that guide DRM in the period 2015-2030 are compiled and disseminated in the Sendai Framework. Accordingly, the Sendai Framework for Action is based on four priorities: 1) understanding the disaster risk; 2) strengthening disaster risk governance for resilience; 3) investment in disaster risk reduction for resilience; 4) improved disaster preparedness to provide an effective and Better Rebuild response in recovery, rehabilitation and reconstruction (UN, 2015). From these four priorities, it is possible to better calibrate the social-environmental disaster management models based on the Sendai Framework (Figure 02).

Figure 02: DRM model calibrated by the action priorities of the Sendai Framework 2015-2030.



Source: Prepared by the authors from the Sendai Framework (UN, 2015).

Use of ICTs in DRM

From the contributions of the Sendai Framework for Action, it is possible to realize that while some priorities of action described in the protocol occur at all stages, such as priorities 01 and 02, other priorities focus on specific phases. With regard to the use of ICTs in disaster management innovation, the Sendai Framework is emphatic in emphasizing the importance of these technologies in understanding the risks. According to the protocol, this understanding is important to "perform collection, analysis, management and use of relevant data and practical information. Ensure its dissemination, taking into account the needs of different categories of users" (UN, 2015, p. 9). Through the information and communication management, highlighted in Sendai, it is possible to understand the risks and effect the DRM. That is, making information on disasters widely available and accessible (UN, 2015).

In this sense, we highlight the intensive use of ICTs to "promote real-time access to reliable data, make use of space and information...and use ICTs innovations to improve the measurement tools and the collection, analysis and dissemination of data" (UN, 2015, p. 9). The use and exponential advancement of ICTs not only delineates promising possibilities for the effective use of information resources for DRM but can also contribute to reducing the intensity, frequency and severity of disasters. The challenge is to capitalize on this potential of ICTs to reduce the impact of disasters and enable the construction of resilient communities (ASIMAKOPOULOU; BESSIS, 2010). In order to overcome this challenge, it is fundamental to understand what ICTs are used and how these technologies operate in the phases of DRM and in emergency notification systems (ARCE; CÓRDOBA, 2012; CROWE, 2012, p. 148).

With the recent advances in information and communication systems, the lack of information is no longer a central problem. The great question is the management of this information, translating it into knowledge for decision-making and dissemination (ASIMAKOPOULOU; BESSIS, 2010). There is a huge variety of ICTs that can be used in the flow of communication in disaster management, categorized into different terminologies and specifics such as telecommunication technologies, space technologies and other computer-based technologies (SAGUN, BOUCHLAGHEM, ANUMBA 2009). Given this scenario, the knowledge about how these technologies operate is critical, since misuse of a technology, rather than improving management, can obstruct communication processes and increase the impacts of disasters.

The ICTs used in the DRM can vary according to three factors involved in the process: 1) nature of the risks of disasters: biological, technological, social-environmental; 2) scale of risk management: global, regional, local; 3) models and phases of management: circular or rectilinear, pre-disaster, trans-disaster, post-disaster. Therefore, in order to apply a given ICT in the DRM, one must understand both the scale of the management model and the nature of the disasters, as well as the model and stages of the DRM process. From this understanding, it is possible to determine and implement appropriate ICTs for each model and stage of the management process. In the case of the model based on the Sendai Framework, it is possible to visualize the operationalization of ICTs through action priorities (Table 01).

Table 01: Action priorities of the Sendai Framework in the management phases.

<table>
<tr><th>PRIORITIES FOR ACTION</th><th>PRE-DISASTER</th><th>TRANS-DISASTER</th><th>POST-DISASTER</th></tr>
<tr><td rowspan="3">PRIORITY 1: Understanding disaster risk</td><td colspan="3">"Policies and practices for disaster risk management should be based on an understanding of disaster risk in all its dimensions of vulnerability, capacity, exposure of persons and assets, hazard characteristics and the environment. Such knowledge can be leveraged for the purpose of pre-disaster risk assessment, for prevention and mitigation and for the development and implementation of appropriate preparedness and effective response to disasters."</td></tr>
<tr><td colspan="3">"To promote real-time access to reliable data, make use of space and in situ information, including geographic information systems (GIS), and use information and communications technology innovations to enhance measurement tools and the collection, analysis and dissemination of data."</td></tr>
<tr><td colspan="3">"To promote investments in innovation and technology development in long-term, multi-hazard and solution-driven research in disaster risk management to address gaps, obstacles, interdependencies and social, economic, educational and environmental challenges and disaster risks."</td></tr>
<tr><td rowspan="3">PRIORITY 2: Strengthening disaster risk governance to manage disaster risk</td><td colspan="3">"Disaster risk governance at the national, regional and global levels is of great importance for an effective and efficient management of disaster risk. Clear vision, plans, competence, guidance and coordination within and across sectors, as well as participation of relevant stakeholders, are needed. Strengthening disaster risk governance for prevention, mitigation, preparedness, response, recovery and rehabilitation is therefore necessary and fosters collaboration and partnership across mechanisms and institutions for the implementation of instruments relevant to disaster risk reduction and sustainable development."</td></tr>
<tr><td colspan="3">"To adopt and implement national and local disaster risk reduction strategies and plans, across different timescales, with targets, indicators and time frames, aimed at preventing the creation of risk, the reduction of existing risk and the strengthening of economic, social, health and environmental resilience."</td></tr>
<tr><td colspan="3">"To foster collaboration across global and regional mechanisms and institutions for the implementation and coherence of instruments and tools relevant to disaster risk reduction, such as for climate change, biodiversity, sustainable development, poverty eradication, environment, agriculture, health, food and nutrition and others, as appropriate."</td></tr>
<tr><td>PRIORITY 3: Investing in disaster risk reduction for resilience</td><td colspan="2">"Public and private investment in disaster risk prevention and reduction through structural and non-structural measures are essential to enhance the economic, social, health and cultural resilience of persons, communities, countries and their assets, as well as the environment."</td><td>"To strengthen the design and implementation of inclusive policies and social safety-net mechanisms...towards the eradication of poverty, to find durable solutions in the post-disaster phase and to empower and assist people disproportionately affected by disasters"</td></tr>
<tr><td>PRIORITY 4: Enhancing disaster preparedness for effective response and to “Build Back Better” in recovery, rehabilitation and reconstruction</td><td colspan="2">"The steady growth of disaster risk, including the increase of people and assets exposure, combined with the lessons learned from past disasters, indicates the need to further strengthen disaster preparedness for response, take action in anticipation of events, integrate disaster risk reduction in response preparedness and ensure that capacities are in place for effective response and recovery at all levels."</td><td>"Disasters have demonstrated that the recovery, rehabilitation and reconstruction phase, which needs to be prepared ahead of a disaster, is a critical opportunity to “Build Back Better”, including through integrating disaster risk reduction into development measures, making nations and communities resilient to disasters."</td></tr>
</table>

Source: Prepared by the authors from the Sendai Framework (UN, 2015)

From these priorities of action, it is possible to highlight three particularities of the phases of the management model based on the Sendai Framework: 1) Pre-disaster: need for investment to improve community resilience through structural and non-structural mitigation measures; 2) Trans-disaster: apply pre-disaster response and recovery exercises, including evacuation exercises, training and establishment of support systems for specific areas, in order to ensure a rapid and effective response to disasters and related displacements; 3) Post-disaster: seize opportunities to rebuild better, so as to avoid creating new risks and reducing existing ones (UN, 2015) .In addition to these particularities, the Sendai Framework is emphatic in highlighting the importance of ICTs to manage information in all phases of management through action priority 01.

However, there is an asymmetry in the use of ICTs in the different phases of management. That is, while one technology may be more suitable for the pre-disaster phase, another may be more appropriate in the trans-disaster phase. This asymmetry occurs due to differences in the central structures of the technological mechanisms adopted (CT or IT). Although rigid architecture (television and radio) ICTs contribute to all phases of DRM, they are most commonly used in the pre-disaster phase because there is more time to work on the information before communicating it to its users. On the other hand, open architecture mechanisms (social networks and mobile applications) can be more used in the trans and post disaster phases, as they allow users themselves to share and produce information.

With regard to the operationalization of ICTs in the different phases of management, it is possible to illustrate the types and asymmetries of use by means of the following differentiation (Table 02):

Table 02: Operationalization of the main ICTs in the DRM phases.

PHASE \ ICT	GIS and Remote Sensing	Radio and Television	Mobile Apps (APP)	Mobile Phone and SMS	Social Networks	Radio Amateur	Alert System
PRE-DISASTER	XXX	XXX					
TRANS-DISASTER		XXX	XXX	XXX	XXX	XXX	XXX
POST-DISASTER		XXX	XXX	XXX	XXX	XXX	

Source: prepared by the authors.

a) Social networks (Facebook, Twitter, WhatsApp, Skype, YouTube) are networks created in the Internet environment that allow interaction and sharing of information by people with common interests (LINDSAY, 2011, LIMA, BARBOSA and FANTATO, 2012), the use of social networks in DRM can be perceived in two moments: 1) trans-disaster: used to disseminate information and receive feedback from users through messages received, sent and shared. That is how most emergency management organizations are using social media, including the Federal Emergency Management Agency (FEMA); 2) post-disaster: use of media to receive requests for assistance, monitor users' activities, and use uploaded information to create estimates of damage. Due to the speculative nature, this second form is little used and organizations are limited only to divulging and receiving information on social networks (LINDSAY, 2011, REGINALDO et al., 2013, UN, 2014).

b) Geographic Information System (GIS): understood as a "computer-assisted system for the acquisition, storage, analysis and visualization of geographic data" (FITZ, 2008, p.23). The use of these technologies enables a comprehensive mapping of disaster risks, to better support decision-making and to improve coordination between agencies (UN, 2014); it is used in all phases of management;

c) Remote Sensing: refers to the process of obtaining information from sensors mounted on satellites or aircraft, allowing the mapping of disaster risks, widely used in all phases of management (SAUSEN; LACRUZ, 2015);

d) Alert Systems: These are procedures (carried out by various instruments) through which information about foreseeable threats is collected and analyzed to alert the vulnerable population before a potentially destructive event (MARTÍNEZ, 2007). An example of successful Warning System is what is established in Japan because it makes it possible to predict, plan and respond in advance to tsunami impacts in the region. This system has approximately 650 seismic stations of high sensitivity, which allow to accurately estimate and predict the occurrence of tsunamis (ARCE and CÓRDOBA, 2012), essential in the trans-disaster period;

e) Mobile Apps: Apps can be defined as "software applications designed to run on mobile operating systems" (SUNG, 2011, p. 03), and are widely used in the trans- and post--disaster period (GÓMEZ et al., 2013). In analyzing 250 emergency applications available in the Google Play database, Gómez (2013) identifies five groups of users: victims (59%), rescue workers (14%), rescue volunteers (14%), witnesses 7%), and public in general not affected by emergencies (6%). Among the applications, the global application Disaster Alert (developed by the Pacific Disaster Center), the Japanese application Yurekuru Call (widely used in earthquake alerts), and the Brazilian applications AlertaBLU and AlertaRIO (used in the cities of Blumenau and Rio de Janeiro respectively).

f) Radio and Television: widely used in all phases of DRM (UN, 2010), with high effectiveness for places and people with difficulty accessing technology. Despite being more efficient in the pre- and post-disaster period, radio is also efficient in trans-disasters because it is able to maintain communication in areas impacted by disasters that do not have electricity, and is recommended in emergency kits (Disaster Preparedness Tokyo).

g) Amateur radio: it has the quality to function when all other means of communication collapse due to the impacts of disasters; in this sense they are highly effective in the trans-disaster period (UNDP-APDIP, 2007, UN, 2014). The simple structure and equipment of amateur radios make them more independent from energy and internet infrastructures. This quality of operation, when all other means of communication collapsed, became evident during the Indian Ocean tsunami in 2004 (UN, 2014), and in the disasters that occurred in 2008 in Santa Catarina (CARDOSO et al., 2014) .

h) Mobile telephony and text messages (Simple Message Service - SMS): mobile telephony has potential in the trans and post-disaster phases, as well as an early warning can be used to organize recovery efforts in coordination with those (UNDP-APDIP, 2007, UN, 2014), on the other hand, SMS are important mainly in the trans-disaster period, since they provide a high capacity of messages without jamming communication.

In addition to the disaster management phase, management levels and the scale of disasters are other factors that determine how ICTs are used. A flood at local level requires a specific type of technology, while a flood at regional level has another technological demand. This multilevel feature requires reflection on what the levels of disaster management are and how these levels interact in the different phases of DRM. It must be understood that disaster risk is manifested and perceived in different ways, according to the scope and approach of risk management. According to Cardona (2006, p. 1), "various planning agencies dealing with the economy, environment, housing, infrastructure, agriculture, to mention only a few relevant areas, must be aware of the risks that each sector faces".

It is possible to highlight three factors that vary according to the level of management: 1) Disaster risk resolution: according to a comparison between EM-DAT (global) and S2ID (Brazilian) databases (LUDWIG; MATTEDI , 2016), we can see that the risk is more detailed in the micro scale, because details are lost as they are worked on a macro scale; 2) decisions: decision making as well as information needs in each level are different; 3) social actors and stakeholders. This means that appropriate communication and information tools are needed at management levels in order to make it possible to understand the problem and guide the decision-making process. There are several classifications on the types and scales of different levels of DRM approach. In Brazil, these levels are determined by the National Policy on Protection and Civil Defense (PNPDEC), which provides for the National System of Civil Protection and Defense (BRASIL, 2012). PNPDEC covers the phases of prevention, mitigation, preparedness, response and recovery focused on civil protection and defense.

Regarding the levels of management, PNPDEC includes four levels: 1) National Level: through the National Civil Protection Council (CONPDEC) and a central body defined by the Executive Branch; 2) Regional level: through regional civil protection bodies; 3) State Level: through state civil protection agencies; 4) Municipal level: through municipal civil protection agencies .Among the changes undergone by the structure of the National Civil Protection System, we can notice mainly the withdrawal of regional bodies in 2010, and the lack of state and municipal bodies in 1988. In addition to defining these four levels, the PNPDEC defines the competences of the three federated entities: a) Union: issue rules for implementation and execution of PNPDEC; b) States: to execute the PNPDEC in its territorial scope; 3) Municipalities: implement the PNPDEC at the local level.

Risk communication flows

Since the adoption of the Hyogo Framework in 2005, several countries have made significant progress in DRM. Both in disaster risk reduction at the local and national levels, and at the regional and global levels (SHI; KASPERSON, 2015). Beginning in 2015, with the implementation of the Sendai Framework, new guidelines have emerged with regard to levels of disaster management. The need to address management at different levels is highlighted by the Sendai Framework, because "while disaster risk factors may be local, national, regional or global, disaster risks have local and specific characteristics that must be understood to determine disaster risk reduction measures" (UN, 2015, p. 88) .The importance of intra and intersectoral coordination mechanisms at all levels is another aspect emphasized in Sendai, which also requires a clear articulation of the responsibilities of each of the stakeholders.

It is possible to highlight four levels of management presented by the Sendai Conference: 1) local; 2) national; 3) regional; 4) global. However, the Sendai Framework was explicit in highlighting the importance of the global level through seven global goals, with which it is possible to support the assessment of global progress in achieving the outcome and the objective of this framework (UN, 2015). According to the Sendai Framework, to achieve understanding of disaster risk, the media should:

> ... take an active and inclusive role at the local, national, regional and global levels, contributing to public awareness and understanding, and disseminating accurate and non-confidential information on the risk of disasters, hazards and disasters, including small-scale disasters, in an easy to understand, simple, transparent and accessible way, in close cooperation with the national authorities (UN, 2015, p. 20).

Given the existing operating systems in the DRM, it is possible to subdivide the communication flows of each level into four channels: 1) organization: occurs within each participating organization of the DRM; 2) between organizations: carried out between the organizations involved; 3) between people: between different types of ICTs users (volunteers and management professionals, victims, witnesses); 4) people to organizations and vice versa: on the one hand the flow of communication of risks can occur from people to organizations, on the other hand, it can also come from organizations from different sectors to people (SAGUN, BOUCHLAGHEM, ANUMBA 2009). To minimize social, environmental and economic impacts, DRM involves multiple organizations to collect, analyze, and communicate data and information that supports decision making. In this way, each organization involved in the risk management process has an internal flow of production, processing and communication of information about disasters.

In addition to the flow of communication of risks in the inter- and intra-organizational context, which makes it possible to advance in the discussion about how organizations share information and knowledge, two other channels of communication are fundamental for DRM: a) channel that establishes from user to user: In this channel the communication flow depends on the type of ICTs user and its relationship with the disasters, this understanding allows to improve the technologies according to the peculiarities of the different types of users; b) flow of communication between users and organizations: in this channel the interactive and multidirectional process of communication flow may vary according to the type of ICT user and their relationship with the different organizations involved in risk management.

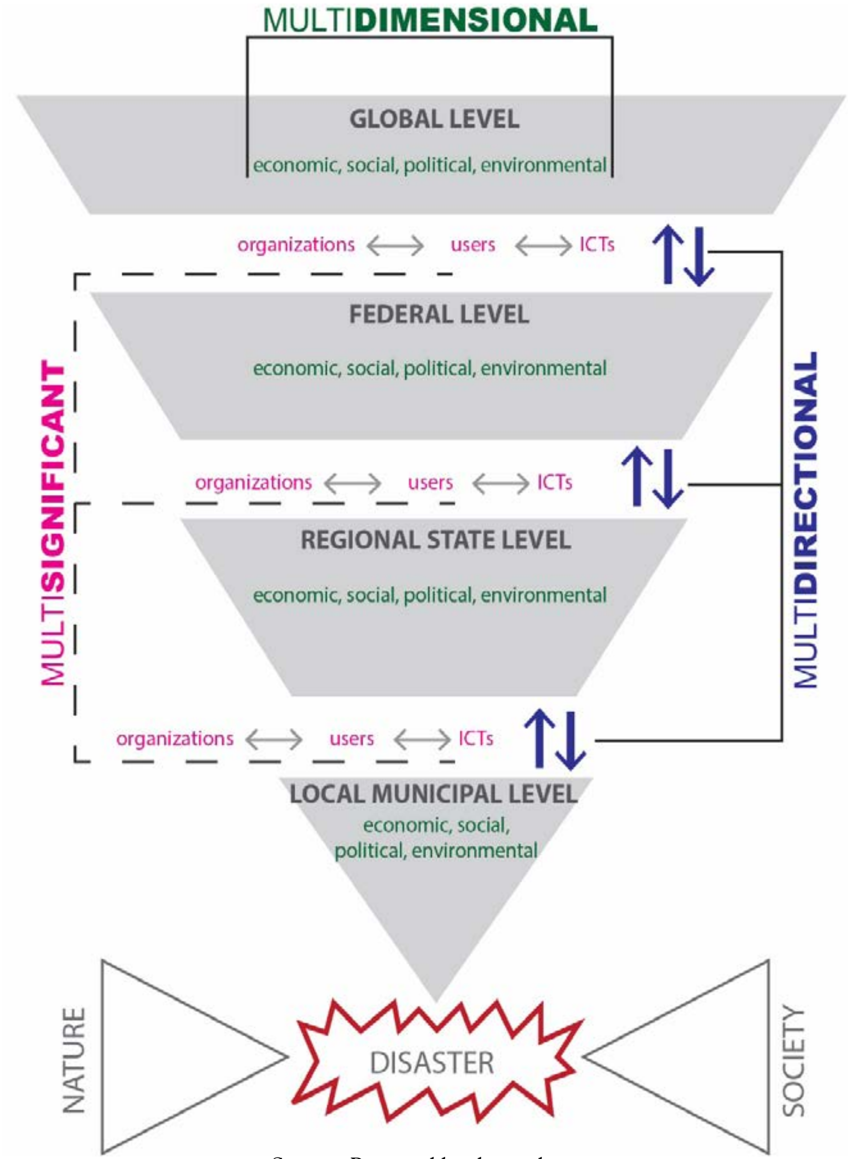
Considering that the collection, processing and sharing of information determine the flow of resources to the affected areas, communication becomes, therefore, a central issue in DRM (DAY; JUNGLAS; SILVA, 2009). However, promoting communication at different levels and between different sectors is a complex task. Depending on the flow of communication between the different levels, an impacted area can receive very little or no resource. This scenario is evident in the Red Cross director's statement: "If you do not communicate your needs effectively then whoever is sending you the resources will continue to send you the resources and after a while you will be caught saying 'do not send any more!' "(*apud.* DAY; JUNGLAS; SILVA, 2009, p. 644). In other words, the flaws in risk communication flows can cause more damage to local development, jeopardizing its recovery, sending little or more resource than necessary.

If the failures do not occur and the impacted region can reestablish its development, the role of institutions at the different levels must be well defined. For this, the DRM requires the existence of organizational and institutional systems and structures that represent these levels and gather different roles in established and agreed coordination modalities (NARVÁEZ; LAVELL; ORTEGA, 2009). Five aspects are relevant to making the flow of risk communication effective: 1) the different phases of the management model, which will indicate the most appropriate technological artifacts to manage and communicate the available information; 2) the different users who use these artifacts: victims, researchers, witnesses, volunteers, professionals; 3) technological artifacts of information and communication; 4) different levels of management, which change the role and approaches of institutions in management; 5) scale and impact of disasters.

In this context, risk communication plays a central role in DRM. Studies on the importance of risk communication began in the United States in the 1980s (VICTOR, 2014). The classic definition points out that risk communication is " an interactive process of exchange of information and opinions between individuals, groups and institutions" (VICTOR, 2014, p. 185). This definition allows to extend the understanding of risk communication to a process beyond the mere transmission of information. Effective risk communication should be based on transparency and reliability, in order to avoid techniques of information manipulation, as well as to seek an interactive process based on the horizontality and multidirectionality of communication, which allows overcoming the superficial polarization between the active transmitter and the passive receiver.

The asymmetry in the operationalization of the analyzed ICTs makes it evident that the processes of risk communication have more resources in the trans- and post-disaster period. However, the flow of risk communication is an ongoing process and plays a crucial role in all stages of DRM (GIROUX et al., 2009; VICTOR, 2014). Therefore, it should not be understood as a final process. Communication flows are essential both in the identification of risk in the mitigation and prevention phases, as well as in the response and reconstruction phases. Given the importance of risk communication in DRM, countries and international organizations should review and strengthen information and

Figure 03: Risk communication flow in the DRM.



Source: Prepared by the authors

communication systems and services.

According to Reginaldo *et al.* (2013), greater emphasis should be placed on the conversion of information into knowledge that assists in decision-making and directing information to different groups of users. Although many forms of ICTs are already being introduced and developed for this purpose (SAGUN, BOUCHLAGHEM; ANUMBA, 2009), caution must be taken so that the problem of coordination and communication is not only associated with technological failures. In many cases, the breakdown in communication is not a product of a shortage of equipment or technological disabilities, but of problems with the contents of information.

By encompassing multiple and complex phenomena, risk communication flows in the DRM may have three cognitive characteristics: 1) multidimensional: production and diffusion of information of an economic, social, political, cultural and environmental nature; 2) multisignificant: the sense of knowledge obtained in the conversion of information varies according to the users, organizations and ICTs involved in the process; 3) multidirectional: the communication flow takes different directions according to the actors, levels, organizations and sectors involved (Figure 03). To get the right information, in the right amount, at the right time, from the right place, to the right person and organization (POPP *et al.*, 2004), these three cognitive characteristics must be analyzed. These considerations make it possible to improve the performance of ICTs in DRM, since they allow the design and operation of ICTs in conjunction with existing organizational and operational systems (DANTAS, SEVILLE, 2006).

5 - Final Considerations

Information is one of the most important resources in DRM communication flows, as it is found and produced by each person, place, and organization. For this reason, risk communication flows can be considered as the basis for decision-making in the DRM. Guiding the way information is communicated between users (victims, volunteers, professionals, researchers, citizens) and organizations (public and private) before, during and after a disaster can lead to new and good practices of DRM. To this end, the operationalization of ICTs in the DRM must be developed and considered from the cognitive characteristics of the communication flow (multidimensional, multidirectional and multisignified aspects). On the other hand, the application of ICTs in the DRM, based on the omission of these characteristics of communication flows, can jeopardize the reconstruction of the impacted region, with a view to "better reconstruction". To improve the use of ICTs in risk communication flows, it is necessary to understand that the more complex the risk, the greater the amount of information that must be collected, addressed and disseminated at all stages by different ICTs.

The analysis of the operationalization of ICTs in the DRM indicates that most technologies are concentrated in the trans- and post-disaster period. More precisely, most ICTs are designed to support response and reconstruction processes, but there is little technology to mitigate and prevent increased vulnerability before disaster strikes. Therefore, there is a need to develop and exploit the use of ICTs capable of operating efficiently in the pre-disaster period. Another aspect that should be considered is the compatibility between the various technologies and between the different DRM actors. As seen, the flow of risk communication will vary according to the type of actor and his or her relationship with disasters. Thus, for cooperation to take place, it is necessary to involve, broaden, encourage and increase the discussion about the role of the different

DRM actors in the production and dissemination of knowledge.

Finally, there is no way to talk about DRM without information and knowledge about the nature, impact and outcome of disasters. This means that the DRM also involves the collection, storage and dissemination of disaster-related information. In this scenario, the DRM is also the management of information and risk communication, being fundamental the conversion of the information in knowledge to create models on the dynamics of the nature and the human activity - in which ICTs constitute the necessary connection between the information generated by an event, in all multidimensions, meanings and directions, and the understanding and communication of this information to users and decision makers.

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Original Article

THE INFORMATION AND COMMUNICATION TECHNOLOGIES IN THE RISK MANAGEMENT OF SOCIAL AND ENVIRONMENTAL DISASTERS

***Abstract*:** The text aims to address the issue of the use of Information and Communication Technologies (ICTs) in disaster risk management (DRM) models. It is based on the different forms of understanding and representation of time in management models. As a result of the literature review, it is argued that the communication flows in the DRM may have three cognitive characters ICTs: a) multisignified; b) multidirectional and multilevel; c) multidimensional. The literature review, used as the main method to develop this argument, structured the text into four main parts: 1) Disaster management models; 2) Use of ICTs in DRM; 3) Communication flow; 4) Final considerations.

***Keywords*:** disaster; management model; ICT; communication flow; Sendai Framework.

***Resumo*:** O texto tem como objetivo abordar a temática da utilização das Tecnologias da Informação e Comunicação (TICs) nos modelos de gestão dos riscos de desastres (GRD). Tem como base as diferentes formas de entendimento e representação do tempo nos modelos de gestão. Como resultado da revisão bibliográfica desenvolvida, argumenta-se que os fluxos de comunicação na GRD podem possuir três características cognitivas: a) multisignificado; b) multidirecional e multinível; c) multidimensional. A revisão bibliográfica, utilizada como principal método para desenvolver esse argumento, estruturou o texto em quatro partes principais: 1) Modelos de gestão dos desastres; 2) Uso das TICs na GRD; 3) Fluxo de comunicação; 4) Considerações finais.

***Palavras-chave*:** desastre; modelo de gestão; TIC; fluxo de comunicação; Quadro de Sendai.

***Resumen*:** El texto tiene como objetivo abordar la temática de la utilización de las Tecnologías de Información y Comunicación (TICs) en los modelos de Gestión de Riesgos de Desastres (GRD). Basado en las diferentes formas de comprensión y representación del tiempo en los modelos de gestión. Como resultado de la revisión bibliográfica desarrollada, se argumenta que los flujos de información y comunicación en la gestión de riesgo de desastres pueden haber tres características cognitivas: a) multisignificado; b) multidireccional y multinivel; c) multidimensional. La revisión bibliográfica, utilizada como principal método para desarrollar este argumento, estructuró el texto en cuatro partes principales: 1) Modelos

de gestión de los desastres; 2) Uso de las TICs bajo la GRD; 3) Flujo de comunicación; 4) Consideraciones finales.

***Palabras clave*:** desastre; modelo de gestión; TIC; flujo de comunicación; Marco de Sendai.