Chapter 21
Disaster Risk Management in the State of Rio de Janeiro

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Abstract This chapter describes and analyzes the recent evolution of disaster risk management in the state of Rio de Janeiro as evidenced through empirical observation, a bibliographic review, and a desk review. Firstly, it describes the two most serious types of hazards – floods and landslides – and shows which territories are more susceptible to risks. Then it introduces the political and institutional context at the state and municipal levels (primarily the civil defense agencies) and details their evolution in reaction to several disasters that have occurred over time. In 2011, the mega disaster in the Serrana region marked an evolution in policies in the state of Rio de Janeiro and Brazil. It triggered a paradigm shift from solely disaster management practices, focused on response and recovery, to broader risk management initiatives focused on risk assessment, prevention, mitigation, preparedness, response, and recovery. Several institutions started to concentrate on risk management, especially in risk assessment and preparedness, for the two types of major hazards. The State Civil Defense, the Environmental State Institute, and the State Department of Mineral Resources were particularly relevant institutions in this context.

Keywords Disaster risk management · Flooding · Landslides · Institutional capacity · State of Rio de Janeiro

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21.1 Introduction

Disaster risk management (DRM) is a permanent process of analyzing, planning, decision-making, and implementing a diversity of measures to (a) identify, prevent, and reduce the possibility of disasters occurring, (b) respond appropriately should one occur, and (c) recover livelihoods, services, and systems following any such occurrence (EIRD 2004; Narváez et al. 2009; CIF-OIT 2012). This concept is an extension of the disaster management approach and emerged from recognizing that disaster risks originate from societies with unsustainable patterns of development (Maskrey 1993; PNUD 2004; UN 2011). Risks are the result of hazards in territories where communities and infrastructure are both exposed and vulnerable. As long as social, environmental, and infrastructure-related vulnerabilities persist, disaster risks will also be prevalent. Owing to the social production of risk, some are critical of the denomination "natural disasters" also used in Brazil, since only hazards are, in fact, natural.

The DRM approach incorporates this broader understanding of risk. It is a part of sustainable development management and has been promoted since 1999 by the International Strategy for Disaster Reduction (EIRD 2004) and more recently as part of the Hyogo Framework for Action (UNISDR 2011) for the period 2005 to 2015 and the Sendai Framework (UNISDR 2015) for the period 2015 to 2030.

DRM may be represented in six components: (1) risk assessment, (2) risk prevention, (3) risk mitigation, (4) preparedness for the occurrence of disasters, (5) response to disaster, and (6) recovery (Fig. 21.1).

The state of Rio de Janeiro (RJ) is in the list of the six states of Brazil with the greatest number of disasters, having suffered several extreme events associated with flooding and landslides in the last decade (CEPED 2013). However, only recently has DRM been recognized for its strategic relevance in sectoral policies for the environment and civil protection and defense (INEA 2014; SEDEC 2015). The main exception to this general configuration is the city of Rio de Janeiro, which, due to its high risk of landslides, initiated a risk management strategy in 1966 through the creation of the Geo-Rio Institute. The purpose of the institute was to perform inspections and determine measures to guarantee public safety. That public authority's pioneering work gained recognition as a geotechnical agency of excellence, since its activities drastically reduced the number of deaths associated with landslides[1] in the city of Rio de Janeiro.

This chapter hones in on the significant transformations in policy that took place as a result of a mega disaster in the Serrana region of RJ in 2011, which caused almost 900 deaths and left more than 300,000 people homeless. Instead of emphasizing purely on response and recovery ("disaster management"), "disaster risk management" started to be embraced. Here, we describe how DRM has evolved in RJ and analyze if the way that it has been managed is far from or close to the concept of "disaster risk management."

[1] http://www.rio.rj.gov.br/web/smo/geo-rio

Fig. 21.1 Key processes in disaster risk management. (Source: Adapted from Narváez et al. 2009)

Exploratory research methods were used (Botelho and Cruz 2013), including bibliographic research, desk review, and empirical observation. The authors consulted reports, official documents, databases, and the websites of the main institutions involved in the research topic, giving priority to documents less than 10 years old. The results are presented in the style of a qualitative narrative: the main hazards in RJ, the institutional configuration in the sector, the main initiatives and changes in risk disaster management, and final considerations.

21.2 Natural Hazards and Disasters in the State of Rio de Janeiro

An analysis of the federal database of recognized emergencies or public calamities (MI 2016b) reveals that floods and landslides are the most frequently occurring natural disasters in the state, representing 86% of all registered occurrences between 2003 and 2016 (Fig. 21.2). Brazilian legislation defines a disaster as "the outcome of adverse, natural, or human-caused events from a situation of vulnerability, causing serious disruption to the functioning of a community or society, including extensive human, material, economic or environmental losses and damages, and exceeding any capacity to contain the events by individual means" (MI 2012).

Municipal civil defense agents have confirmed the prevalence of floods and landslides (SEDEC 2015) (Fig. 21.3). Of the state's 92 municipalities, 37 declared landslides as the main hazard, while 43 others declared that landslides were among the five main hazards. As for floods, only one municipality did not cite that disaster as one of the five main hazards (SEDEC 2015).

The frequent occurrence of floods and landslides in the state is due, to a large part, to its high pluviometric indices, rugged terrain, and hydrographic particularities (compare Nehren et al. 2018). The rivers of the state's sierra present elevated hydraulic speeds, which are marked by transient floods with heightened erosive

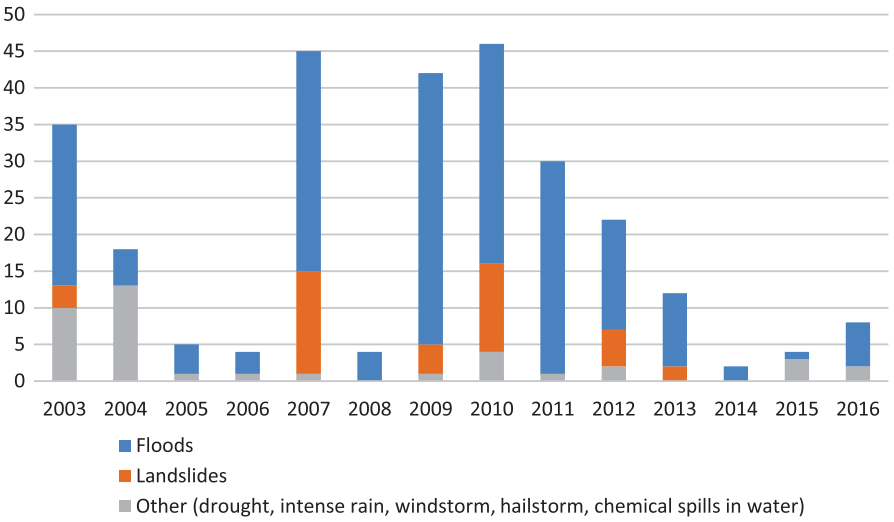

Fig. 21.2 Number of natural disaster occurrences in the state of Rio de Janeiro, January 2003 to 2016. (Source: Based on data from National Civil Defense Secretariat – SEDEC (MI 2016b))

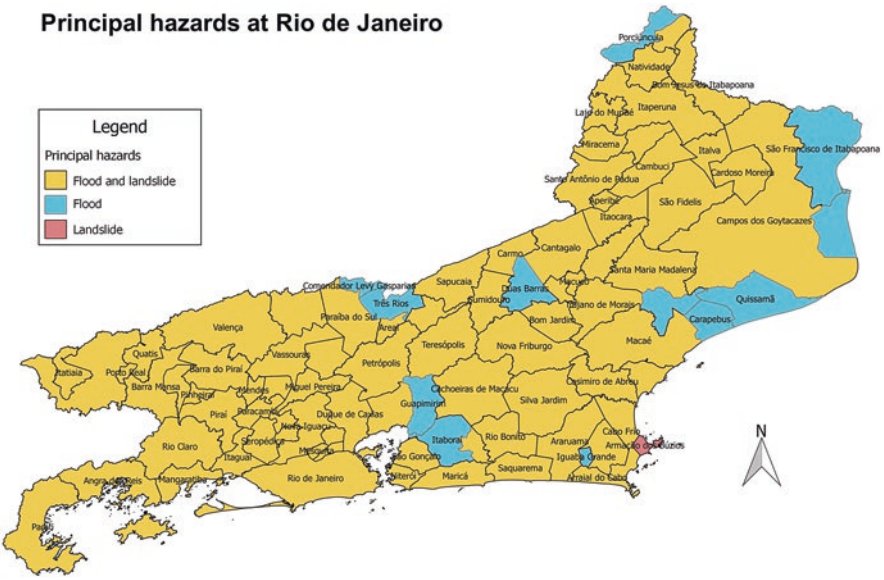

Fig. 21.3 Principal hazards in the state of Rio de Janeiro. (Source: Authors, based on data from Civil Defense College (SEDEC 2015))

capacity (Canedo et al. 2011). According to the geo-environmental map of RJ (*Mapa Geoambiental do Estado do Rio de Janeiro*; CPRM 2000), almost 40% of land in the state is highly susceptible to erosion, landslides, and rockfall, 37% is moderately susceptible to erosion, and only 8% presents low susceptibility. Sedimentation plains make up 12% of the state's lands.

The impacts of such events are compounded by several factors. Populations are increasingly exposed to hazards owing to their irregular occupation of hillsides, riverbanks, and floodplains. Their vulnerability is increased by the proliferation of self-constructed houses and sub-housing units, precarious sanitary conditions, and the inhabitants' overall low socioeconomic profile (INEA 2014). Due to these factors, the existing risks are of much greater consequence in urban areas.

In the period 1991 to 2012, almost 80% of all recorded flood and landslide disasters in Brazil occurred in RJ. In the decade 2000, the respective number of occurrences was 21.7 times greater than in the decade 1990. This shows a 3.6 times greater increase in floods and landslides than the rate of all recorded disasters of both periods in general.

In recent years, several disasters of notable magnitude have taken place: landslides in Angra dos Reis and Ilha Grande (01/01/2010), a flood in the city of Rio de Janeiro (05/04/2010), landslides in Niterói (Morro do Bumba, 07/04/10), and especially the mega disaster that affected seven municipalities in the Serrana region (11/01/2011). The average number of affected individuals in the period from 2007 to 2010 was 500,000 persons/year (MI 2016b), excluding the disaster that occurred on 05/04/2010, which affected 6 million people.

The flash floods and landslides in the Serrana region in January of 2011 caused the greatest number of deaths in Brazil since 2000. With an estimated 865 deaths, more than 16,000 left homeless and almost 305,000 people affected in the sierra's seven municipalities (SEDEC 2012), it was considered one of the world's ten worst landslide disasters in the last 111 years (CRED 2011). The losses and economic damages incurred by the municipalities were also extraordinary, being estimated at R$ 4.8 billion (IBRD 2012). Notably, this amount does not take into account the impacts sustained by the education and health sectors, for which there are no estimates.

This mega disaster occurred due to a combination of critical, natural factors and adverse meteorological conditions, associated with chronic, historical processes of environmental degradation and irregular human settlements on steep slopes, riverbanks, and hilltops (INEA 2014). According to the Ministry of Environment (MMA 2011), such areas, which are protected by law as Permanent Preservation Areas (Áreas de Preservação Permanente – APPs), were precisely those most affected by the disaster. According to that report, of the 657 landslides analyzed, 92% involved anthropic alteration, and only 8% occurred in preservation areas with native vegetation. Accordingly, the report highlighted that a great proportion of impacts and damages could be minimized if anthropic intervention did not occur in APPs. That conclusion reinforces the importance of preventive measures that work toward harmonizing legislation for land preservation and land management practices.

21.3 Policies for Disaster Risk Management and Institutional Framework

Following the disaster in 2011, the federal government promoted important changes in the legal, political, and institutional spheres in favor of disaster risk management at the national and state level.

One year after the disaster, the federal government approved a legal framework for civil protection and defense (Federal Law n° 12.608/2012): the creation of a new national policy and new institutions (Viana 2016). The National Civil Protection and Defense Policy (PNPDC in Portuguese) gave strong priority to risk reduction measures for natural disasters. Innovative measures were introduced that favored greater coordination between disaster risk management and other social and environmental policies. The abovementioned law delegates the authority to assess and monitor at-risk areas to the federal and state governments, as well as the responsibility of supporting municipalities in performing preventive urban planning. The law also establishes that preventive and mitigative measures must be adopted by all three levels of government.

The Federal Government program, *Programa 2040*, has been part of the last two "Pluriannual Plans" (for the periods 2012–2015 and 2016–2019) and is geared toward risk and disaster management. This program has had a significant evolution in policy inasmuch as it involves several federal governmental entities: the Ministries of National Integration and of Cities, the National Water Agency (ANA), the Geological Survey of Brazil (CPRM), the Brazilian Institute of Geography and Statistics (IBGE), and the National Center for Monitoring and Early Warning of Natural Disasters (CEMADEN). The program's measures emphasize adaptation and reduction of vulnerabilities rather than focusing only on tracking hazards (MI 2016a).

At the state level, in RJ the three central institutions for disaster risk management are the Sub-Secretariat of Civil Defense (SEDEC/RJ), the State Environmental Institute (INEA), and the State Department of Mineral Resources (DMR). While the SEDEC has extensive practical experience in administration related to disasters, INEA and DRM possess technical and scientific expertise concerning risks. The number of professionals that work in disaster risk management in each of the three entities is also rather different (see Table 21.1). Together, these are examples of obstacles in achieving greater integration between those institutions.

SEDEC/RJ, which has existed since 1996, has the Military Firefighter Corps (CBMERJ) as a subordinate entity. CBMERJ's main responsibility is search-and-rescue, and it also promotes preventive measures related to building security. Together, SEDEC/RJ and CBMERJ represent the state's capacity in preparing for and responding to disasters. In 2012, SEDEC/RJ began a change from the disaster management to the risk management approach, with emphasis on risk assessment and preparation. SEDEC/RJ's work plans can be outlined in the following groups: (a) preparedness, (b) response actions, (c) recovery, and (d) technical/operational support. Concerning the latter group, a notable measure was the creation of the

Table 21.1 Characteristics of institutions for disaster risk management

	SEDEC/RJ	INEA	DMR
Number of staff	16,042 (firefighters)	1130	90
Number of staff for disaster risk management	504	82	10

Data from 2013

Center for Monitoring and Early Warning of Natural Disasters (Cemaden/RJ), whose technical team puts out warnings of disasters (SEDEC 2017).

The INEA, created in 2007, has the purpose of administering state policies concerning the environment, water resources, and forestry. In the context of geo-hydrometeorological risks, INEA provides information and executes projects and works. Its DRM operations consist of (a) prevention, mitigation, response, and reconstruction and (b) monitoring and warning. An analysis of its operations reveals that the institution does not apply a systemic approach to risk management (GITEC/IP/CODEX 2014a).

The purpose of the DMR is to manage and promote the sustainable use of mineral resources, oil resources, and underground water resources. Its activities have included geological risk prevention since 2009. The DMR also plays the role of providing information aimed at supporting SEDEC/RJ and municipalities. Its two groups of operations are: (a) preventive and (b) operational and instructional.

After the disaster in the Serrana region, INEA and DMR significantly increased their production of studies assessing and analyzing flood- and landslide-related risks. INEA also augmented its monitoring network and hydrometeorological alert system and developed new projects to track and mitigate floods. Moreover, the disaster in the Serrana region revealed that the then-current model of institutional and operational management of disaster risk management was inefficient. The need to harmonize and integrate procedures between institutions becomes evident. Thus, INEA, SEDEC/RJ, and DMR coordinated a study aimed at elaborating the terms of an institutional and operational restructuration for geo-hydrometeorological disaster risk management in RJ and achieving greater coordination between the three institutions (GITEC/IP/CODEX 2014a, 2014b). Although the study was concluded in 2014, by 2017, none of its recommendations had been implemented.

The study included an assessment of municipal capacity for risk management (GITEC/IP/CODEX 2014b), which demonstrated that, in 2013, 82 out of the state's 92 municipalities generally:

- Invested in improving their technical and administrative capacity for civil defense
- Developed more measures for prevention and mitigation than for preparedness and recovery
- Developed little measures for coordination and participation

A weighted analysis of this data revealed that, in 2013, 22 municipalities presented satisfactory results regarding their approach to DRM. The municipality of Rio de Janeiro ranked first and far ahead of all others, validating its long experience in DRM (GITEC/IP/CODEX 2014b).

21.4 Main Initiatives and Changes in Disaster Risk Management

The most relevant measures implemented in RJ following the disaster in 2011, which stemmed from recent political and institutional changes, are detailed below.

21.4.1 Assessment and Analysis

A large proportion of the data, studies, and assessments has been produced within the past decade. The available data is recent (disasters after the year 2000), which hampers the ability to assess the effects of floods and landslides from previous years and their magnitude. Gaining a more realistic understanding of the related risks is, thus, also hindered.

As a part of the "Programa 2040," CPRM is designing maps that detail susceptibility to gravitational mass movements and floods (1:25,000) for the municipalities of RJ that are considered priorities. Maps have already been completed for 50 of the state's municipalities (CPRM 2017). CEMADEN and CPRM (2017) also design maps outlining landslide risks (vulnerability, susceptibility, and aptness for urbanization). Many of those maps possess scales that do not provide significant detail (>1:25,000), but they have nevertheless been used in support of other instruments for planning and urban and environmental management (Viana 2016).

Since 2010, DMR-RJ has analyzed landslide risks. The institution has created products at several scales, such as maps outlining susceptibility, geotechnical aspects, and risks. It has even created maps on imminent risks (for the majority of RJ's municipalities) and remaining landslide risks. Maps detailing imminent risk of landslide have been elaborated for 67 of RJ's municipalities, and maps detailing remaining risks have also been created for the municipalities affected by the disaster in the Serrana region (Teresópolis, Nova Friburgo and Sapucaia) (DRM 2017).

INEA has collaborated in identifying and assessing flood risks and producing maps that portray susceptibility, danger, and risk of floods in some river basins or particularly critical sections of certain rivers (INEA 2015). The information provided is capable of defining criteria to clear riverbanks and resettle populations residing in those areas. In addition, INEA created a methodology to assess natural susceptibility to flooding (Napoleão et al. 2016). Notably, flood risk assessments were developed for critical river stretches of four (of a total nine) of the hydrographic regions in the state of RJ (Piabanha, Rios Dois Rios, Médio Paraíba do Sul, and Baía de Guanabara) (INEA 2017).

The state water resources plan (PERHI-RJ) includes a report on vulnerability to extreme events containing important diagnostics of the most critical areas for geo-hydrometeorological disasters (INEA 2014). The report was elaborated with data obtained from assessments of critical occurrences of floods and inundations, land-

slides, droughts, and fires—despite the existing registers of such events being limited and incomplete.

While significant advances have been made recently, the knowledge needed to reduce the disaster risks of floods and landslides is still lacking. Susceptibility and vulnerability assessments must be performed to integrate and complement existing studies. Priority should be given to river basins with more dynamic land use and high-intensity rainfall indices. Notably, information systems and databases on risks and disasters are not available.

21.4.2 Prevention and Mitigation

Driven by the consequences of the mega disaster that occurred in 2011, RJ passed State Law 6.442 in 2013, which reinforces an essential requirement of the national policy that master plans and other regulatory instruments for land use and occupation must incorporate studies and assessments of risk factors and flood and landslide risks. This law is considered an advance for land management as it means that the knowledge produced on disaster risks should be collated for the purpose of the master plans, with municipalities being designated as the main prevention agents. Yet, in many municipalities risks have still not been studied. Only in a few isolated cases has the effective application of the related legislation been assessed during the revision process of such master plans.

With the aim of reducing flood risks, projects of flood control and environmental recovery have been developed in the areas affected by the disaster of 2011 in the Serrana region. Examples include the creation of environmental protection areas, river parks and riverbank recovery to improve drainage, recovery of riverbank areas, and the proposal of further measures to avoid the resettlement of at-risk areas (INEA 2015).

21.4.3 Preparedness

Preparedness includes hydrometeorological monitoring and warning, the establishment of early warning and response protocols, training of responsible authorities, and field exercises. Such precautions are taken to be able to respond to the probable occurrence of a hazard.

Since 2008, great advances have been made in the implementation and expansion of hydrometeorological monitoring networks. Protocols and systems have been established for early warning of floods and landslides, such as INEA's flood warning system (Bahiense et al. 2015) and the CEMADEN/RJ. In 2014, two meteorological radar systems were also installed to allow real-time monitoring of rainfall in the territory of the state.

Early warning systems against landslides operate based on the correlation between rainfall and landslides in diverse scenarios of risk (DRM 2016). They also involve monitoring by community agents and distress sirens to warn the population of at-risk areas.

Amid the state's economic crisis, from 2016 onward, there have been reports of hydrometeorological systems and early warning and alarm systems being partially or fully impaired (Fantti 2017; O Globo 2017). Such circumstances underscore the challenges in providing adequate operation and maintenance to these systems.

21.4.4 Recovery

The catastrophe in the Serrana region forced the relevant public authorities to protect the unaffected part of the population, to reestablish a situation of normalcy, and to restructure the main locations affected to diminish disaster risks. The measures undertaken include the following:

- Hydraulic sections from the damaged bridges were inspected and measured.
- Diverse areas were cleared.
- River channels were recomposed.
- Flood control and environmental recovery projects were undertaken in the most affected municipalities, including river dredging and canalization.
- New bridges were built.
- River parks were created.
- Families formerly living in areas of imminent flood risk were resettled (Júnior et al. 2013).

State Decree 43.415/2012 established guidelines for the relocation of the families affected by disasters and payment of a social allowance until definitive resettlement.

21.5 Final Considerations

RJ's history attests to the territory's high risk of loss of life and material damage from flood and landslide disasters. Vulnerability is particularly high in urban areas, where more than 96% of the state's population resides.

The mega disaster that occurred in 2011 evidently marked the evolution of policies in this sector—in RJ and in Brazil. Perceptions of the problem and of possible solutions were expanded, moving past a focus exclusively on disasters to encompass the management of disaster risks as well. Important legal and institutional changes occurred at the federal and state level, demonstrating an incorporation of this new vision. Notably, a profusion of initiatives took place to produce data, assess and survey risks, and standardize regulatory instruments for land use and occupa-

tion. Thus, the institutions made their operations increasingly reflect an optic of risk management, based mainly on the two most prevalent types of hazards (floods and landslides).

However, the effectiveness of these initiatives in reducing existing risks and preventing future ones in every municipality's territory must still be assessed. An evaluation of emerging initiatives in the municipality of Nova Friburgo (the one most affected by the disaster in 2011) revealed that while many advances had been made, overlapping authorities, duplicated efforts, communication problems between institutions, and a lack of methodological planning to harmonize the different initiatives were prevalent (Viana 2016). For example, several government entities undertook risk mapping with the aim of establishing restrictions and guidelines for land use and occupation. However, the scales, methodologies, and technical criteria adopted for each of those documents were sometimes not well-understood or accepted by the municipality's technical team. Thus, the materials ended up being suboptimally used for urban planning efforts that aimed at reducing risk disasters. In sum, many important measures were implemented, but adjustments must be made to integrate them in an effective and efficient local risk reduction strategy.

In general, although much has been accomplished in terms of risk reduction, the federal institutions concerned and the government of RJ still focus a great deal of their efforts on confronting disasters with more robust and integrated measures for preparedness, response, and reconstruction.

Finally, it is recognized that the challenges of disaster risk reduction are still great in technical terms and mainly in terms of governance. These challenges are greater still in the nation's current context of economic crisis, which engenders worries for the continuity of measures that have been already initiated and operationalized. The interruption of those measures could directly impede the capacity of the state and its municipalities to manage disaster risks.

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