



A PARTICIPATORY AND INTEGRATED FLOOD RISK MANAGEMENT EXPERIENCE: BELO HORIZONTE, BRAZIL

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ABSTRACT: Floods are one of the most destructive disasters that occur in the city of Belo Horizonte, located in the southeastern region of Brazil. Between the years of 1991 and 2010, these processes caused dozens of deaths, affecting nearly 300,000 people. In order to mitigate those losses, the Belo Horizonte city government adopted a systemic risk management approach. In this sense, structural and non-structural measures were implemented, with a strong focus in community involvement, which helps to improve the local understanding of flood risk. These measures are internationally recognized and, due to its efficiency and applicability, should serve as an example. Therefore, the objective of this study is to describe the participatory and integrated flood risk management strategy and the community mobilization initiatives conducted by the Belo Horizonte municipality. For this purpose, technical visits were performed at different departments of the city. One of the most relevant preventive action identified was the continuous training and mobilization of the population that lives in flood prone areas, through the Centers for Rain Warning and Alerts (NAC). These centers, composed by government officials and community members, allow the establishment of a direct channel of dialogue with the people affected by floods, which improves the inhabitant's perception of risk and the effectiveness of disasters response and recovery. Since the implementation of these measures there was a significant decrease in the quantity of people affected by floods. The major factor that contributes to this success is the application of social technologies that include the participation of vulnerable communities both in knowledge of the problems and in finding out solutions. Another important factor is the constant interaction of the departments of the city government in the risk management. Thus, Belo Horizonte has achieved a reduction of vulnerability and is becoming a safer city for its inhabitants.

Key Words: Flood Risk, Integrated Flood Risk Management, Civil Defense, Community Mobilization initiatives.

1. INTRODUCTION

Floods are natural phenomena for lowland rivers that always have occurred and will always continue to occur in the future (Bruijn, 2004). However, when they happen associated with occupied areas, they leave many people unsheltered, causing economic losses to the affected people, social impacts and, in extreme cases, loss of human lives.

These processes are one of the most destructive disasters that occur in the city of Belo Horizonte, located in the southeastern region of Brazil. Only between the years of 1991 and 2010, floods caused dozens of deaths, affecting nearly 300,000 people in the municipality (Ufsc and Ceped, 2012). These hydrometeorological disasters are the result of the natural predisposition of the terrain allied to the expansion of the city without taking into account the proper spatial planning criteria. Due to these characteristics, several regions of Belo Horizonte, most of them located in informal settlements, have problems related with the occurrence of floods, triggered in periods of heavy and intense rainstorms.

To prevent floods from becoming disasters and to reduce their impacts, it is necessary to consider flood risk management strategies. Thus, the Belo Horizonte city government adopted a systemic risk management approach, in order to enable the city to cope with flood waves. In this sense, structural and non-structural measures were implemented, with a strong focus in community involvement, which helps to increase the resilience and improve the local understanding of flood risk. These measures are internationally recognized and, due to its efficiency and applicability, should serve as an example for other municipalities.

Therefore, the objective of this study is to describe the participatory and integrated flood risk management strategy and the community mobilization initiatives conducted by the Belo Horizonte municipal government, with a special emphasis on risk prevention and in flood emergency response. Furthermore, this study aims to reflect about the risk management system employed, with regards to the advances provided by these measures, as well as their challenges and difficulties.

2. FLOODS IN BELO HORIZONTE

Belo Horizonte (BH) is the capital of the State of Minas Gerais, Brazil, with a territory of 330 km², of which 95% is already urbanized (Ibge, 2011). The city lies at 19°55' South latitude and 43°56' West longitude (Figure 1) and has an altitude of 750 to 1,300 meters. It presents a clearly defined seasonality, with two seasons: rainy and dry. The rainy season lasts from October to March, when 88% of the total yearly rainfall occurs and, consequently, most of the flood events. The highest monthly average rainfall (315mm) takes place in December (Paolucci, 2012).

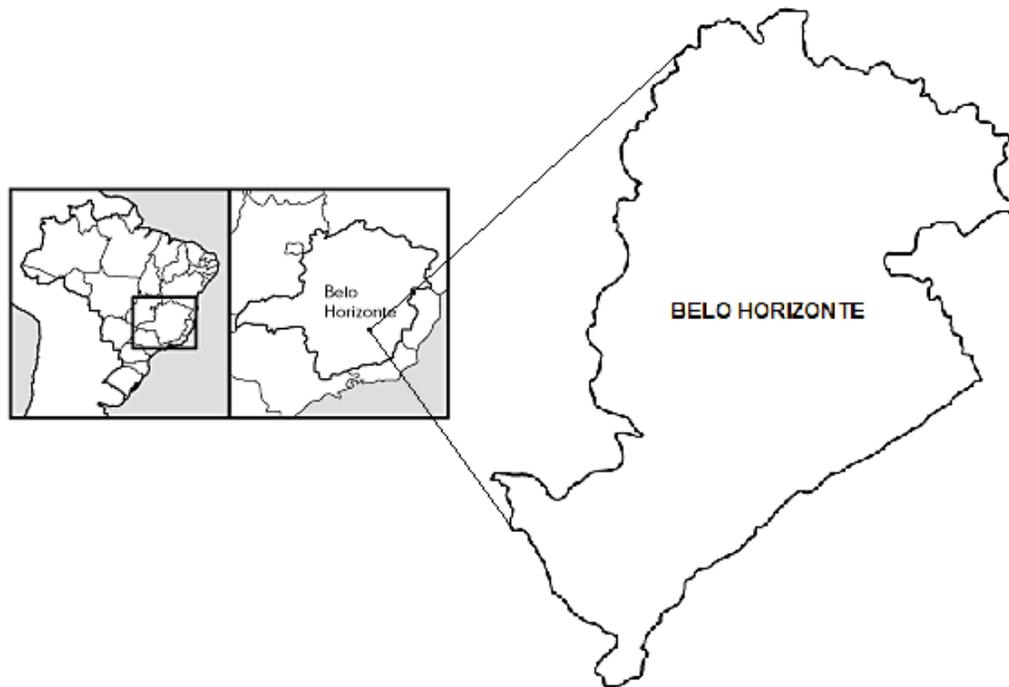


Figure 1: Location of the municipality of Belo Horizonte, Minas Gerais, Brazil

Belo Horizonte is affected by floods since its foundation in 1887 (Champs, 2012). At that time, the city had only 12,000 inhabitants (Baesso, 2006). However, in the following decades due to migration processes, there was a significantly increase on the population, achieving 1,235,000 inhabitants in 1970 and 2,340,000 inhabitants in 2010 (Ibge, 1973; 2011). The inequalities in the distribution of income and land access, associated with the urban expansion that was characterized by disordered growth, led to the proliferation of informal settlements. These settlements were established mainly in flood prone areas, occupied by poor people precisely because the land is less valued and inappropriate for legitimate construction. Therefore, during the last decades flood disasters have become more frequent and have

increased in magnitude of damage. Champs (2012) emphasizes that this increase in flood frequency is a result of the accelerated process of urbanization that occurred in BH, and that there is a close correlation between the population growth and the number of flood events, as shown in Figure 2.

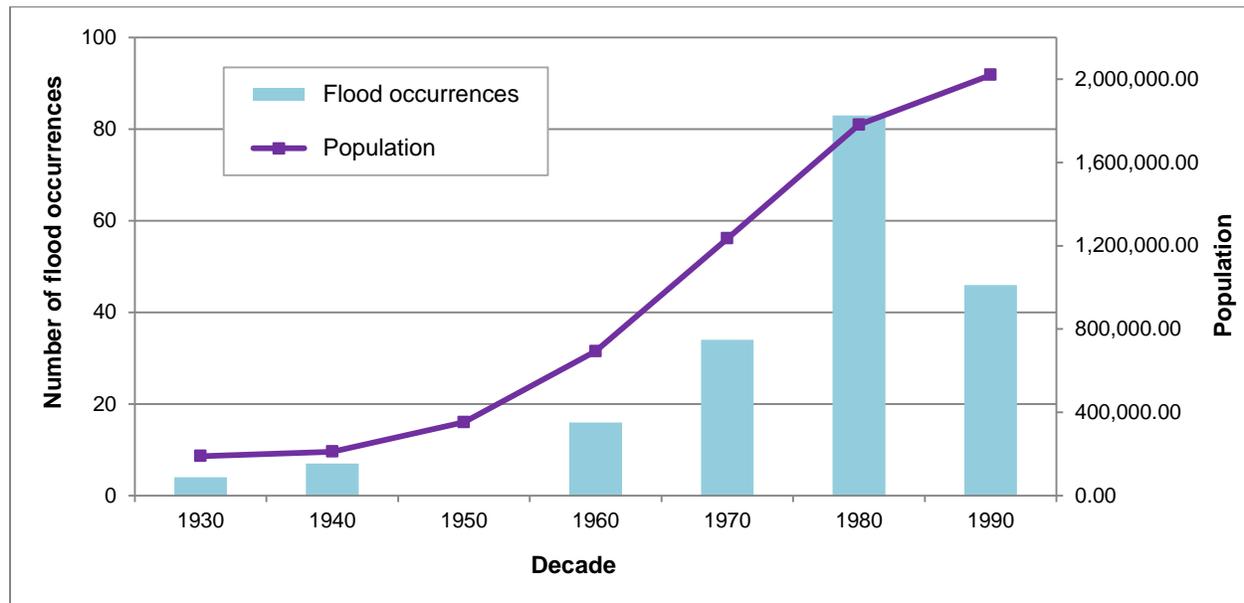


Figure 2: Number of flood occurrences (bars) and population growth (dotted line) from 1930 to 1990 (Champs *et al.*, 2012)

Belo Horizonte has two main catchments: the Arrudas creek and The Onça creek, which are tributaries of the Velhas River and the Pampulha River (Diener *et al.*, 2013). Due to the accelerated process of urbanization, the natural conditions of those rivers have changed significantly during the last decades. Nearly 200 km of watercourses were channeled in the central area of the city, merely coated or confined in closed channels. The Arrudas River, which crosses the city, is channeled in about 1/3 of its length, mainly at the most urbanized part of the city (Aroeira, 2010). Thus, the Arrudas River has become one of the main conditioning factor for the occurrence of floods in the center of BH, since the reduction of the natural curves of the rivers increases the speed of the water, directing and driving more broadly the excess water downstream. Furthermore, the imperviousness of the soil had increase and consequently the stormwater runoff rate (Duarte, 2009).

3. PARTICIPATORY AND INTEGRATED RISK MANAGEMENT IN BELO HORIZONTE

Understanding the importance of improving the resilience of communities for flood preparedness and response, the Belo Horizonte municipality had established several strategies to make the city able to cope with floods. In this sense, it is worth to note that the Belo Horizonte City Government was one of the first municipalities in Brazil that adopt the risk management as a local public policy, enabling the establishment of a long-term vision for the city, which embraces an increase of its resilience.

The participatory and integrated flood risk management strategy adopted by the city government allowed the reduction on the number of houses located in risk areas. The number of families that lived in areas prone to floods and landslides decreased from 15,000 in 1994 to 10,650 in 2004, to 3,789 in 2008 and, finally, to 2.761 in 2011, with an overall 80% reduction of the risk situations. Furthermore, the number of losses of lives due to floods and landslides was reduced significantly in recent years, as shown in Figure 3. As an example, in the 80's, 111 deaths were recorded, while in the 90's the number of fatalities was 44 and in the 2000's, this value has decreased to 32 deaths. It is believed that the introduction of non-structural measures since de 1990's, such as rainfall alert systems, removal of families at risk and revitalizing streams, contributed to this reduction.

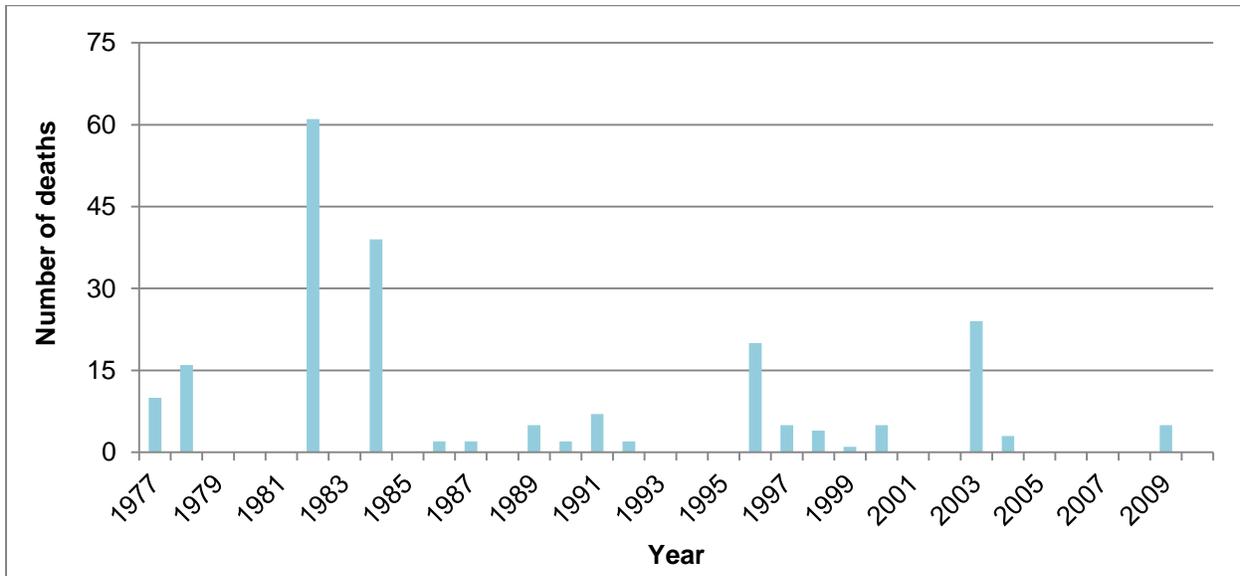


Figure 3: Number of deaths due to floods and landslides between the years 1977 and 2010 in Belo Horizonte (Prudente and Reis, 2008; Paolucci, 2012)

Due to its commendable progress in reducing disaster risk by the cooperation between local residents public utility companies and private businesses, the Belo Horizonte municipality received in 2013 the United Nations Sasakawa Award for Disaster Reduction. The theme for 2013 Sasakawa Award was “Acting As One”, which aim to draw out disaster risk reduction is everybody’s business.

In order to understand the structure of the Belo Horizonte City Government regarding flood management, technical visits were performed at different departments and offices of the city. Those visits were coordinated by the Municipal Civil Defense Council (COMDEC-BH). The following items present the main projects and programs developed in Belo Horizonte that aim to mitigate risk areas and damages from adverse events, carried out by different levels of the city government.

3.1 Structural Program in Risk Areas (*Programa Estrutural em Áreas de Risco - PEAR*)

The Belo Horizonte municipality established in 1993 the Structural Program in Risk Areas (PEAR), developed by the Belo Horizonte Urbanizing Company (URBEL), which was based on the model of the United Nations Disaster Relief Organization (UNDRO). Within the scope of this program, emergency and structural actions to reduce geological risk situations are developed. This program also emphasizes non-structural measures, such as community mobilization initiatives, land use planning based on risk areas, as well as the improvement of the legislation concerning natural hazards.

During the dry season, the PEAR team performs preventive inspections, monitors the flood prone sites and executes small and medium-sized structural works to mitigate risk situations. The PEAR is also responsible for removing people from risk areas to safer locations when it is essential to ensure safety. In the rainy season, the attention is focused on the monitoring of flood subject areas (Cerri and Nogueira, 2006).

The PEAR works in constant collaboration with the community. Civil Defense centers (*Núcleos de Defesa Civil - NUDEC*) were formed with residents of risk areas who are trained to understand and adopt preventive measures. They participate in task forces in which small preventive works are carried out with the Community labor and technical guidance of Belo Horizonte City Council.

3.2 Storm Water Strategic Plan (*Plano Diretor de Drenagem Urbana - PDDU*)

The Storm Water Strategic Plan (PDDU) was developed between the years of 1999 and 2001, and is used as a planning tool for the management and operation of flood control services, with a strong environmental focus. The PDDU directs the decision makers not only on specific issues such as flooding, but also on the macro drainage systems to be adopted. This program is housed by the Superintendence for the Development of the Capital (SUDECAP).

As part of the PDDU, the BH municipality has performed drainage systems studies, covering issues related to soil erosion, water pollution, the occupation of the banks and floodplains of watercourses, canals stability, urban planning and legislation concerning the land use and occupation. To help with this, it was created a Geographic Information System (GIS) applied to the dynamic of drainage system in BH, called "Drainage-GIS" (Champs *et al.*, 2001). This allowed the creation of an interactive web platform which managers and technicians can access to gather drainage system information on the hydrographic basins and urban environment.

Flood modeling studies were also conducted in 2009 at the Arrudas and Onça creeks catchments. The modeling of these processes allowed the development of a Flood Hazard Map for the Belo Horizonte City, which indicates the critical areas subject to floods. Throughout this study, 82 flood prone areas were mapped, which comprise a total of 9,000 habitations (Smurbe and Sudecap, 2009). Based on this map, the BH City Government installed more than a thousand educational boards in order to instruct people to avoid the critical areas in case of intense rainfall and, thus, reduce flood damages. Examples of these boards are shown in Figure 4.



Figure 4: Warning signs installed in flood areas (Left picture: "Avoid transiting on this site in case of heavy rain"; Right: In case of heavy rain avoid moving forward, turn right")

3.3 Belo Horizonte Environmental Recovery Program (*Programa de Recuperação Ambiental de Belo Horizonte - DRENURBS*)

The Belo Horizonte municipality implemented in 2002 a program entitled Belo Horizonte Environmental Recovery Program (DRENURBS). This program aims to reduce the flood risk by improving drainage systems and urban environmental management, by restoring the quality of waterways and by keeping natural the remaining natural creeks of BH. The DRENURBS was designed to enhance the involvement of local communities in decision making process, in order to spread knowledge to foster the empowerment of the local citizens.

Due to the prominence of this Program in the urban water planning and management, BH was chosen in 2005 to be one of the 9 cities participating in the SWITCH Project (Sustainable Water Management Improves Tomorrow's Cities' Health), led by the IHE (Institute for Water Education), of the UNESCO. This Program aimed, among other actions, to promote inclusion of the local community in the management decisions. Moreover, the DRENURBS received in 2010 an honorable mention award from the Metropolis

Awards, granted by the World Association of Major Metropolies, which contemplated projects and experiences that focused on the improvement of the population resident in urban areas.

3.4 Centers for Rain Warning and Alerts (*Núcleos de Alerta de Chuva - NAC*)

In order to continuously train and mobilize the population that lives in flood prone areas, the city government established in 2009 the Centers for Rain Warning and Alerts (NAC). These centers are composed by government officials and community members who volunteer their time. They allow the establishment of a direct channel of dialogue with the people affected by floods, which improves the inhabitant's perception of risk and the effectiveness of disasters response and recovery. Furthermore, the NAC centers foster the participation of the local residents in the formulation and execution of mitigation policies and response to disasters.

Until the year 2013, 42 NAC were established, with approximately 350 trained volunteers who act as agents on the alert and emergency warning of other residents, providing support for people with special needs to leave their houses at the time of flooding and indicating them the location of shelters. The alert system was entirely designed with the community participation, through the elaboration of participatory flood hazard maps, commonly called as "spoken floodplain maps" (*Mapas de Mancha Falada*), as shown in Figure 5. These maps reflect the local reality, witnessed by the community in past flood events. They indicate which levels the water reaches during the occurrence of floods; the location of people with special needs or elderly; support points and places that could be used as shelters; escape routes that can be used; the dynamics of receiving and forwarding rain alerts.



Figure 5: Centers for Rain Warning and Alerts (Left picture: Elaboration of spoken floodplain maps; Right: rain alert communication system)

The spoken floodplain maps allowed the identification of approximately 9,000 habitations located in flood areas in which measures are being implemented to reduce the risk. This social technology encourages the exchange of experiences and disseminates technical knowledge produced by experts, while the local citizens share their knowledge of everyday reality.

3.5 Rainfall Alert Information Center (*Centro de Informações de Alerta de Chuva – CIAC*)

The Rainfall Alert Information Center (CIAC) aims to integrate all meteorological and hydrological information available for the BH municipality in order to use them in the Civil Defense actions. This center is part of the Municipal Civil Defense Council (COMDEC-BH) and operates 24 hours a day, every day of the week during the rainy season.

After receiving the rainfall data, the CIAC makes correlations with the predicted rainfall and the Flood Hazard Map, allowing the identification of the critical locations. From this data, the CIAC determines, when necessary, alert states, indicating the sites with higher amounts of rainfall and higher hazard. Once

the information is analyzed and interpreted, the alert is passed on to the various institutional bodies that act directly on the problems arising from the storms and for the population, through volunteers from the Civil Defense Center (NUDEC) and the Centers for Rain Warning and Alerts (NAC), who also live in risk areas. Alerts are sent by e-mail, telephone, SMS, social networks and the press. From this alert, population can adopt appropriate preventive behaviors.

3.6 Risk Areas Executive Group (*Grupo Executivo de Área de Risco - GEAR*)

Besides the participatory management in BH, there is also a joint management between the URBEL, the SUDECAP and other 27 municipal offices and other institutions: the Risk Areas Executive Group (GEAR). The purpose of this group is to give more agility to assist the population affected by disasters, as well as to optimize human and material resources for this activity.

Among the group's purposes, it's emphasized the search for the immediate resolution of problems that occur by optimizing human and logistical resources from all the city government. For this purpose, the GEAR members meet weekly during the rainy season, when there is a greater probability of natural disasters occurrence. These meetings are intended to promote the exchange of information about risk situations. This information refers to, for example, the dissemination of the inspections performed, the recovery needs of the disasters that happened, the request of food supplies, the daily monitoring of precipitation and the exchange of knowledge (Paolucci, 2012).

The solutions are built together, with technical, logistical and material contribution of those who have vocation and possibility to act. Actions and deadlines are established and in the next meeting the ongoing actions and the agreed practical results are checked. The major gain of the methodology is the possibility of adding solutions and contributions from all participants. Thus the sum of large and small contributions produces better results.

4. CONCLUSIONS

The Belo Horizonte municipality has developed a successful risk management program concerning floods, based on the systemic view that everyone has something to contribute. The participatory approach adopted involves local stakeholders and the technicians from different levels of the city government. It consists essentially of preventive measures, such as fostering the community participation and the transfer of knowledge to the involved people, removing them from risk areas to safer locations and the development of emergency plans based on a network of Rainfall Alert Information centers.

Since the implementation of these measures and due to the better flood preparedness of the population, there was a significant decrease in the number of injuries, deaths and damages caused by floods. The major factor that contributes to this success is the application of social technologies that include and expand the participation of vulnerable communities both in knowledge of the problems and in finding out solutions. Another important factor is the constant interaction of the departments of the city government in the risk management, which should be encouraged and pursued by other municipalities.

This methodology has proven to be suited for the Belo Horizonte municipality, because it allows the incorporation of local knowledge in decision making process, what places the city at a prominent position between the Brazilian metropolises. Thus, Belo Horizonte has achieved a reduction of vulnerability and is becoming a safer city for its inhabitants.

In spite of the advancements provided by these measures, difficulties still persist on handling urbanization, particularly the spreading of informal settlements, because the land use legislation do not properly consider impacts of urbanization on water in an effective way. In this manner, about 360,300 inhabitants still live in shantytowns located in flood and landslides prone areas. So, further progress still needs to be done in terms of urban development planning, and of course long term measures focusing on the social and economic inclusion of people living in risk areas.

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