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What influences disaster risk perception? Intervention measures, flood and landslide risk perception of the population living in flood risk areas in Rio de Janeiro state, Brazil

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ABSTRACT

The flooding and landslides catastrophe in 2011 in the mountainous area of Rio de Janeiro State in Brazil affected more than 300,000 people and created unquantifiable material losses, mostly in the Nova Friburgo Municipality. Even with the available technologies, programs and measures for disaster prevention, the population was not prepared. Following international frameworks like the Hyogo, governmental institutions related to risk management started working with the population to improve response, preparedness and perception. This work aims to evaluate disaster risk perception (DRP) and intervention measures of the population living in flood risk areas and relate it to variables such as landslide risk perception, experienced disasters and intervention measures taken from institutions and the population. Through 391 quantitative questionnaires and 20 semi-structured qualitative interviews, we reveal the connection between DRP, the people who may be affected and the strategies for response and preparedness of the institutions. Using descriptive statistics, factor analysis and regression, we develop six main factors related to risk perception. The regression defines flood risk perception (FRP) as the dependent factor and exposes the small influence on FRP from state and municipal institutions working with disaster risk reduction (~ 0.01) in comparison to past experiences (~ 0.52), demographic characteristics (~ 0.29) and local influences (~ 0.62). Supporting literature about DRP, examples about institutional influences are given. Hard and soft intervention measures exemplify neighborhoods developing perceptions according to institutional influences, local organization strategies and marginalization level, highlighting the importance of local participation on risk reduction programs to improve perception, trust and therefore, intervention measures.

1. Introduction

The frequency of extreme water related risk events worldwide is increasing, as is the number of people affected and the damage caused by such events [1,2]. Floods and landslides impinge upon human security and therefore affect sustainable development [1,3]. Absolute prevention or absolute protection against floods through management is unachievable, and something which goes beyond management is needed [4]. Risk appraisal and perception modifies risk management decisions and, therefore, management actions [5], making it a crucial aspect. Several researchers (Slovic, Sjöberg, Paton, Slovic and Weber, Sjöberg et al., Burns, Lindell and Hwang) have defined disaster risk perception (DRP) as the motivator of priority settings, preventive activities and resource allocation [6]. Recent research on flood risk perception (FRP) highlighted the importance of knowing the causes for determined protective actions, intervention measures (IM), trust in public and private protective measures, and perception on risk management responsibilities [7]. Rainfall-runoff monitoring and flood forecasting modeling processes are essential technical processes for disaster risk management. Adding social dimensions as understanding, knowledge exchange and local perception, increases the effectiveness in management [7]. Some difficulties of social dimensions, such as local perception, are that they are dynamic according to specific location, situation and influences [8,9]. Defining and understanding variables and factors determining DRP and the influence of IM in specific areas might provide public and private institutions with a valuable vision to better develop disaster risk management strategies. Considering landslides, droughts, IM and other variables in the specific area of Nova

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Friburgo, we take flood risk perception (FRP) as a main and dependent factor for DRP because of the history of occurrence on the area and the intervention of public institutions (Section 1.1).

This paper aims to analyze and determine the factors related to DRP taking FRP as the dependent factor and the population living in the flood risk areas of Nova Friburgo Municipality in Brazil as the specific case. Through factor analysis and correlations of quantitative questionnaires complemented with qualitative semi-structured interviews, the following research questions are addressed: 1) What are the most influential factors that affect FRP in the area? 2) What is the influence of public institutions on DRP in comparison to civil societies initiatives? 3) How do these factors interrelate with and influence specific DRP?

As part of the introduction, Section 1.1 explains the Rio de Janeiro (RJ) and Nova Friburgo (NF) risk management and warning system. Section 1.2 provides the definitions of FRP and IM used for this paper. The methodology for the selection of the population, questionnaires type, data collection and statistical processing is described in the second section. The third section presents the resulting correlation of FRP to the variables measured and the interaction of the factors with IM taken in the area, discussing their relation to public institutions and civil society. Specifically, Section 3.1 describes and analyzes the correlation of the variables with FRP. The questionnaires contain four principal indicators for protective mitigation behavior, divided into soft and hard measures according to the definition of the United Nations Office for Disaster Risk Reduction UNSDR [10]. The willingness and the capacity to move out of a risk area, contention measures and reforestation are among the hard intervention measures (HIM) detailed in Section 1.2. Among the soft intervention measures (SIM), we consider knowledge about risk maps, preparedness courses, knowledge about sirens and evacuation points, communication on safety actions and existing SMS groups for risk alarms. All SIM are detailed in section 1.3. In addition, Section 3.4 further discusses the influence of public institutions working on disaster risk reduction and local influence is analyzed and compared between the selected areas before the conclusions in the fourth section.

1.1. Flood risk, landslide risk and warning system in RJ

Rio de Janeiro is the first industrial state in the country, demonstrating considerable economic growth after the economic recovery of the last 20 years. This significantly changed migration patterns in the whole state. Producing more than 82% of the national oil production, and with a GDP per capita of 26,250 R$ (± 8402 US$) [11], there was an evident increase in the dynamism of the social, economic and environmental spheres. Consequently, the urban expansion and informal settlements have also increased during recent years. Nova Friburgo was one of the most affected municipalities, together with Teresópolis and Petrópolis. It has a population density of approx. 200 hab./km2 [12] and is the fourth most populated municipality in the State.

Flash floods, floods and landslides have long affected the state of Rio de Janeiro, especially on the west to east mountain chain that reaches more than 2000 m.a.s.l. The orographic barrier blocks the oceanic currents coming from the south provoking heavy rainfalls on the mountainous region. The years 1986, 1997, 2005 and 2007 were some in which severe rains caused several floods with severe consequences [13]. The frequency and magnitude of these phenomena are both due to the climatic, geomorphologic and geologic characteristics of the area (e.g. tropical climate, weathered soils and extensive mountainous areas) and to the presence of areas characterized by high population density and unplanned and spontaneous land occupation [14]. Nevertheless, the flash floods and landslides of January 2011 were the worst disaster in Brazil in terms of human losses and people losing their houses and livelihoods to the floods and landslides, resulting in more than 900 deaths and 300,000 affected people, as confirmed by official data [15]. However, following calculations based on around 8844 electricity meters lost (887 in Nova Friburgo) and registrations in the electric power company (Energisa) that were never rehired, it has been suggested that actual losses were 8–10 times greater [16,17].

On the night of 10 January 2011, the national meteorology institute INMET registered 166 mm of rain for Nova Friburgo city, which is 70% of the monthly average for January. The soil was saturated because of a rainy month, so the water level rose in a couple of hours. A representative of the Geological survey service (DRM), affirms that the strong thunders during the rain were triggers of the landslides and the thin soil layer above the rock, characteristic of the mountainous areas, contributed to the hundreds of landslides. Roads, communication, energy, water and sanitation facilities were destroyed leaving some regions isolated, as one dweller in Nova Friburgo confirmed: “on the third day after the tragedy I still couldn’t know if my family on the other side of the city was alive”. Public infrastructure was lost and productive sectors were also affected, the World Bank estimated a total of R$ 2.2 billion ($1.3 billion) costs in direct damages. Houses and buildings located in or close to steep hills and close to the rivers were destroyed leaving around 39,000 people homeless or displaced, most of them were informal housing (favelas). As one of the dwellers described about Sao Jose neighborhood: “the entire neighborhood was under debris, unrecognizable”.

The National Center for Natural Disaster Monitoring and Alert (CEMADEN) at national level and the Secretariat of Civil Defense (SEDEC) in Rio de Janeiro State are responsible for articulating technical information received by the federal and local governments related to possible climatic events. This information is mostly provided by the State Institute for the Environment (INEA) and the Geological Survey Service of State (DRM), according to the new institutional rearrangement [18], created to define specific processes and products of the institutions working on disaster risk reduction in the State [19]. After the 2011 floods and landslides, local and international institutions focused on infrastructural and non-infrastructural projects in the most affected areas. After reconstruction projects, led mostly by the state or municipal government with federal resources, institutions related to risk management, environment and land use had to increase research and improve their work with the local population. Federal funds were released to increase the response and preparedness through awareness and training programs.

The INEA created the Center for Information and Environmental Emergencies (CIEM). This monitoring and warning system is a simple model. Water level information from telemetric monitoring stations is sent in real-time to INEA webpages, and a warning level (red, yellow or green) is displayed according to stream overflow level calculations previously made for every station. This information is also sent by SMS to the registered population when thresholds are surpassed. DRM risk maps are based on digital elevation model maps and historical information about previous landslides and developed in GIS by local technicians. Civil Defense (CD) and the municipal prefecture work directly with people who may be affected. They offer preparedness courses free of charge, survival kits, evacuation simulations with the installed sirens, information and have developed a SMS alert system together with INEA. International institutions like Care International and the Red Cross, national institutions like INCID, IBASE and organized neighborhood associations and active citizens’ groups also undertake different activities with the population living in risk areas in order to improve their knowledge and protection, as well as preparedness.

1.2. Disaster risk perception framework

The definition of DRP is based on several approaches. From a rationalist approach, an evaluation of benefits versus cost (gains and losses), to a constructivist approach, which defines risk perception as a dynamic practice imposed and shaped by societies, showing that many elements must be taken into consideration. In essence, we define risk perception as a predecessor of mitigation behavior or IM, as is classified