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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, 1987; Sjöberg, 1999; Paton, 2001; Slovic and Weber, 2002; Sjöberg et al., 2004; Burns, 2007; Lindell and Hwang, 2008) 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 ac-

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cording 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 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 by Bubeck et al. [20] and Birkholz et al. [7] specifically for floods. Mitigation behavior, defined by the UNISDR as practicing the limitation of adverse impacts of hazards and related disasters, is generally divided into hard intervention measures HIM (e.g. infrastructure, technology) and soft intervention measures SIM (e.g. policy, instructional, communication) [21,22]. Among the constructivist approaches, the protection motivation theory presents four factors that define a preservation behavior: perceived severity of a threat, perceived probability of occurrence, perceived usefulness or effectiveness of any recommended response and perceived ability to implement response [7]. Bubeck [20], classifies the first two as threat appraisal and the third and fourth as coping appraisal.

DRP defines IM, but also intervention measures taken, will influence on DRP. It is important to consider that in addition to the four factors previously mentioned there are many external factors that can change perception. The IM strategies used by the people who may be affected depend mainly on three things: improving knowledge of causes and likelihood of flooding, social memory of past events and reduction of reliance on public structural measures [7]. The first two measures are basically dependent on SIM (e.g. communication to increase knowledge and experience of the surrounding areas, policies for risk alarms). Only the third is a perception of structural measures like contention walls. Among the factors considered, FRP is strongly affected by socio-economic and demographic characteristics [23–25] and previous experiences [26]. Johnson et al. [27] and Tierney [28] also defended the premise that social construction of risk is dynamic and often imposed by power structures and unequally experienced by marginalized groups. In this sense, we separate public power from civil society influences on DRP of each of the dwellers in the neighborhoods studied.

In order to have an idea of the causes of FRP, a regression is used to evaluate different variables. Threat appraisal (severity and probability of occurrence) is measured and taken as a dependent factor while coping appraisal, experiences of past events and demographic factors are measured and taken as independent factors. In this document, the critical analysis is focused on the role of governmental institutions and organizations versus the influence of the local population by shaping flood risk perception in the context of a major disaster that took place in 2011 in Rio de Janeiro.

2. Methodology

The data collection was principally based on questionnaires designed under Taylor-Powell [29] and Walonick [30] methodologies. Questionnaires were held in Portuguese answered by the population living in flood risk areas in a door-to-door survey. These were complemented by semi-structured interviews of the personnel working in the main institutions related to disaster risk reduction in the state (Fig. 1), following Fontana and Frey [31] and Ulrich and Probst [32] methodologies. Most of the data was taken between August 2015 and January 2016. Some expert interviews were held in September 2014 to design the fourth part of the questionnaires, and the first questionnaires were conducted in March 2015 for testing and revision. The selected sub-basin, Rio Dois Rios, has an area of 4.375 km2 and a population of

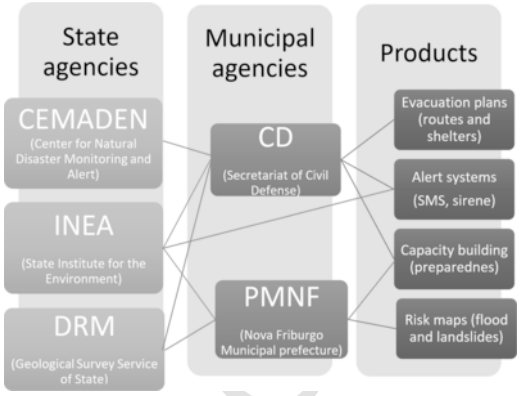

Fig. 1. Institutions working in the studied area.

371,255 inhabitants; it is composed totally or partially of 12 municipalities, all of them in Rio de Janeiro State. Nova Friburgo (985 m.a.s.l.) is the head of the basin, was heavily affected in 2011, and thus it was selected as a focus municipality. Bom Jardim, Trajano de Morais Sao sebastiao de alto and Sao Fidelis were selected for comparison and validation purposes, as part of the Rio dois Rios basin (Fig. 2).

Households in rural (n = 115) and peri-urban (n = 276) risk areas were selected for the questionnaires. An official delimitation of the risk areas (both in rural and in urban areas) was given by INEA, based on a flood model created with the HEC HMS and HEC GIS programs by Ecologus, a consultant outsourced after the 2011 tragedy. Based mainly on the DEM and a 15–30-m buffer zone around the rivers, official flood risk maps were developed, locating red (high flood risk in the buffer zone) and yellow (mid-flood risk near the buffer zone) zones and highlighting the houses located in both risk areas for Campo de Coelho (CC), Corrego Dantes (CD), and Rio Grandina (RG). These maps were made to plan a green protected area around the river in the most affected areas in the municipality of Friburgo, and also to relocate the population living in these risk areas.

Out of around 385 houses officially marked as under severe risk on INEA risk maps, 160 were demolished or abandoned, from the 225 houses standing in the risk areas, 217 (56%) responded to the questionnaires. The abandonment was driven by fear of a new event or under a contract with INEA where they received a house in the "Minha casa minha vida" federal program, or received state or federal assistance to cover the monthly payment for a rented house. For the non-official risk areas in Sao Fidelis (SF), Barracao dos Mendes (BM), and Terra Nova (TN) the methodology was repeated, and houses were marked, following the DEM maps, methodology and buffer zone described by INEA. Representing rural areas in Sao Fidelis (SF), Barracao dos Mendes (BM) and peri-urban areas in Terra Nova (TN), the population living near the river participated in the same questionnaire. With the results, a contrast of the perceptions between rural and peri-urban areas, as well as official and non-official sites was evident. Table 1 shows the reported areas' division between rural - urban, unofficial - official INEA risk areas and some basic demographic data.

The questionnaire had four main parts: 1) General demographic data; 2) Previous experiences with natural disasters and adopted mitigation measures; 3) Perception of risk (severity and likelihood), and 4) Coping appraisal. Previous experiences with natural disasters and adopted mitigation measures (point 2), reflected mainly personal experiences during and after the tragedy of 2011 and previous disaster events; response measures taken during and mitigation measures taken after. This second point helped the interviewee to become familiar with the subject; many of them gave confident details and specifications about their experience.

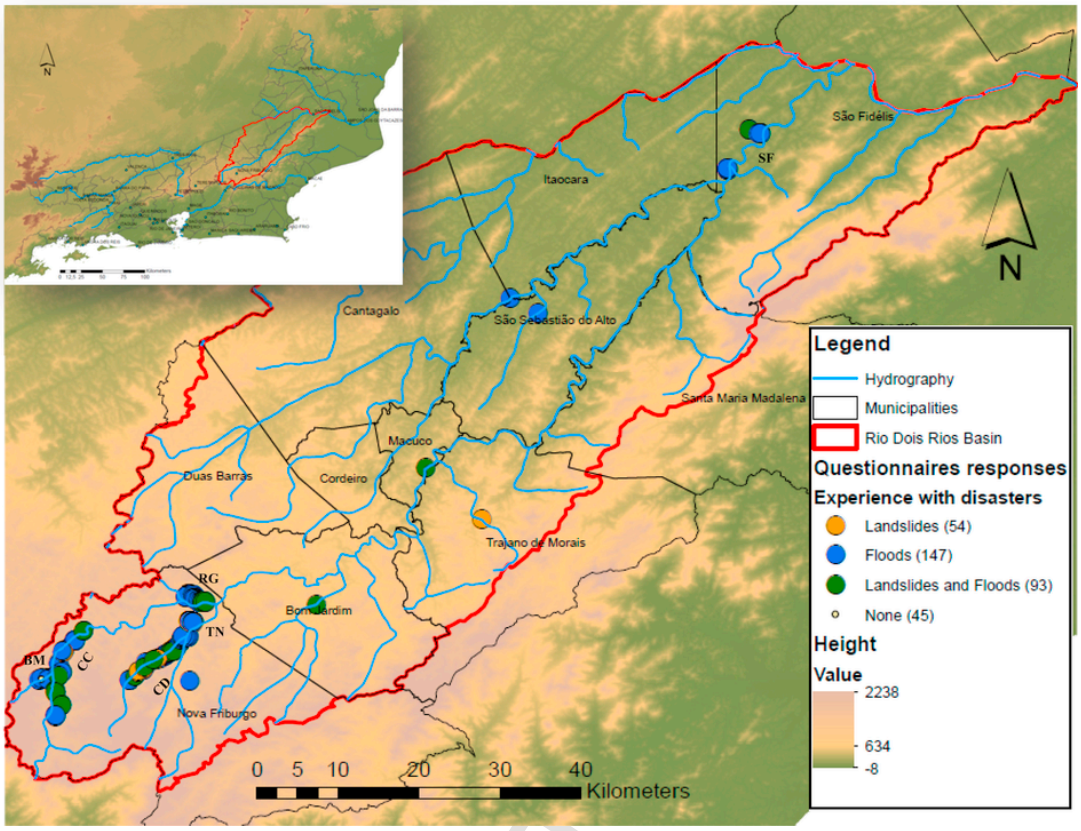

Fig. 2. Rio dois Rios sub-basin area and interview points.

Table 1
General data of the interviewed population.

Location of the neighborhoods	Rural areas		Peri-urban areas				Total
			Official INEA risk areas				
	SF	**BM**	**CC**	**CD**	**RG**	**TN**	
	Sao fidelis	Barracao d. Mendes	Campo do Coelho	Corrego Dantes	Rio Grandina	Terra Nova	
Number of questionnaires	21	49	45	124	48	104	391
Gender (female percentage)	71.43	42.86	40.00	45.97	62.50	32.69	44.76
Average (Av.) age in years	49.86	38.82	28.98	47.05	54.65	34.09	41.57
Av. years living in the area (%)	24.38	18.84	11.82	27.08	34.92	6.18	19.55
Access to media (0–4 items: radio, TV, phone, internet)	3.33	2.71	1.84	3.25	3.13	2.12	2.71
Av. pop. with formal work (%)	57.14	87.76	68.89	65.32	50.00	38.46	59.08
Av. pop. retired (%)	9.52	6.12	15.56	14.52	27.08	11.54	15.09
Av. pop. unemployed (%)	33.33	6.12	15.56	20.16	22.92	50.00	25.83
Av. affected by inundations (%)	95.24	79.59	57.50	83.06	72.92	34.62	65.47
Av. affected by landslides (%)	2.80	36.73	31.11	89.19	14.40	82.59	28.39

Perception of risk (point 3) evaluated their knowledge and the perception they have about their risk state; the likelihood of a future event where they live (flood or landslide) evaluated in a scale from one to four and how severely they could be affected evaluated qualitatively. Flood risk perception of the residence (from no risk at all to high risk) is the independent variable for the correlation (Table 2).

Coping appraisal (point 4) evaluated response efficacy and self-efficacy; the influence of the state and municipal institutions in their preparedness (e.g. infrastructural vs. non-infrastructural measures) and measures taken by them for preparedness, possible long/short-term measures financial or physical help received from institutions, family and/or neighbors. Using affirmations previously made by institution experts, we could ask the population about their knowledge about specific programs and projects aiming to educate the population and increase preparedness. This point also evaluates people's perception of their environment, knowledge about rainy – dry season, natural surroundings and the importance of reforestation activities and ecosystem services.

The factor analysis in SPSS divided the 42 variables (26 main + 16 secondary) into six main factors: general demographic information (e.g. years living in the area, gender, age, working sector, telephone, internet access), geographical location (e.g. distance to the urban cen-

Table 2
Parts, factors and variables of the quantitative questionnaires.

Questionnaire	Main factors	Main variables	Secondary variables
Part 1. General demographic data	1. General demographic information	Years living in the area, gender, age, telephone and internet access	Working sector, TV and radio possession, priority subject in the area,
	2. Geographical location	Geographical location (distance to the urban center, river, street, schools and hospitals)	Altitude
Part 2. Previous experiences with natural disasters and adopted mitigation measures	3. Previous experience with risk events	Quantity of previous experienced floods, quantity of previous experienced landslides, evacuation process taken, contention measures taken, appraisal of preparedness level	Date and severity of last events, intention of relocation, economic capacity of relocation
Part 3. Perception of risk	**Flood Risk Perception (independent variable)**, landslide risk perception,		
Part 4. Coping appraisal	4. Knowledge of ecosystem-based disaster risk reduction measures	Eco-DRR knowledge, reforestation effects, green areas' importance, infrastructure value, local surroundings	Knowledge on rainy seasons, knowledge on risk areas nearby
	5. Local influence	Information about possible risk events from family and friends, help received from family and friends, knowledge from experience, knowledge family and friends' experience,	Precautionary actions from family and friends, satisfaction with received help
	6. Institutional influence	Information about possible risk events, from institutions, help received from institutions, information from the INEA system alert, knowledge about existing risk maps, participation in CD capacity building,	Precautionary actions from institutions, satisfaction with received help, knowledge of web pages of alert, response to alert signals, appraised utility of alert signals

ter, distance to the river, street locations, schools, hospitals), previous experience with risk events (e.g. experienced floods, experienced landslides, evacuation and contention measures), knowledge of ecosystem-based disaster risk reduction measures (Eco-DRR, reforestation effects, green areas' importance, infrastructure value, local surroundings), local influence (e.g. information and help received from family and friends, knowledge by own and family and friends' experience) and institutional influence (e.g. knowledge of the INEA system alert, knowledge of existing risk maps, participation of CD capacity building).

For the data analysis of the quantitative data of the questionnaires, categorical responses were coded into numerical scales with four options (from not at all to very much) plus an open-ended option. Open ended questions were qualitatively analyzed and recoded into new categories. After simple descriptive statistics, a factor analysis (based on an original correlation matrix of the variables involved) was conducted in SPSS. A simple linear regression (Ordinary Least Square with link, beta and robust test) was run with Stata for the analysis of all variables. The regression analysis considered flood risk perception as the dependent factor and the 26 main variables as independent factors. After a link, beta and a robust test, and some graphical methods for inspecting data including Cook's D, the quantity of observations was reduced to 302, excluding all cases in Sao Fidelis and other municipalities, which were at the end of the basin and had different flooding conditions (< 0.02).

The 20 semi-structured interviews conducted by the author lasted from one to two hours and were addressed to experts working in institutions and living in the risk areas, selected by snowball sampling method. At least one dweller of each area working in a committee or mentioned by the surveyed people and at least two representatives of all institutions described in Section 1.1 (Fig. 1) were selected, including technicians working in specific risk programs (like CIEM in INEA). In the case of institution experts, subjects were related to the functioning and organization of the institution, their relation to other institutions and their relation to the people who may be affected. Data about alert systems, preparation and preparedness programs was analyzed and separated into categories comparable from institution to institution. These categories were used for the formulation of the fourth part of the questionnaire related to institutions influence. Due to the limitations of this paper, discourse analysis was left aside for future analysis. All qualitative data taken was recorded and the aspects related to the six factors was used to qualitatively justify, reinforce or question the quantitative results.. Furthermore, a simple count on intervention measures suggested by the experts opened the comparison between hard and soft intervention measures in Sections 3.2 and 3.3.

3. Results and discussion

This section first places the flood risk in context with other types of disasters occurring in the area. After a description of the main variables affecting FRP, an analysis of the factors they represent highlights the influence of the different stakeholders. In order to describe the specific measures taken, an analysis of specific hard and soft IM is presented. The discussion concludes with clarification of the role of civil society in the study case.

3.1. Perception of potential victims

The questionnaires focused principally on floods and landslides. Droughts came up as a subject of discussion in some cases and were later considered for the discussion. Although the river level has considerably decreased in the last three years, drought is not perceived as a problem in these areas. Considering that the population interviewed lived near rivers, the lower water levels were first associated with flood risk reduction more than water scarcity, especially in the peri-urban areas. During the qualitative interviews, experts affirmed that they are not working on droughts since "it is not part of their specific responsibilities or objectives".

The perception of the population about floods was much more concrete than their perception of landslides due to heavy rainfall. In total,

15.56% considered that they were living in a landslide area considered to be dangerous to very dangerous, while 37.50% considered they were living in a flood area considered to be dangerous to very dangerous (Table 3). This perception was common in mountainous areas due to key physical processes that enable easier early recognition of types of floods [33]. Also, floods are historically more frequent than landslides in this particular area. Added to this, the perception of a possibility of new landslides in the interviewed areas was relatively low, many of those interviewed argued that the catastrophe of 2011 was a once in a lifetime event, or as a dweller in CD said: "all that had to slide did already slide". With all these arguments, we used flood risk perception as a central point and dependent variable in the subsequent analysis.

Table 3
Description of experience and perception of floods and landslides (N = 391).

	Population that experienced…	Perception of house in a very dangerous or dangerous location for…
Floods	68,28%	37,50%
Landslides	42,19%	15,56%

After extraction of the cases of Sao Fidelis, as explained in the methodology, the result of the simple linear regression in Stata is statistically significant, Prob > F is equal to 0.00. Since this is an explorative analysis the result of R-square is limited to 0.3393, meaning that only 34% of the FRP may be explained by the studied variables. Fig. 3 shows the main variables and their relation to FRP. The strongest correlation in the figure is with the experience of floods (coef. = 0.52), which is not surprising. Experience increases perceived probabil-

Source	SS	df	MS		
Model	126.41	30	4.21	Number of obs	= 302
Residual	246.17	271	0.90	F (30, 271)	= 4.64
Total	372.58	301	1.23	Prob >F	= 0.0000
				R- squared	= 0.3393
				Adj R-squared	= 0.2661
				Root MSE	= 0.9531

Flood Risk Perception (DV)	Coef.	Std. Err.	t	P>|t|	95% Conf.	Interval
Distance to the urban center	0.0001	0.01	0.82	0.410	-.0001	.0001
Distance to rivers	-0.0075	0.08	-0.09	0.932	-.1811	.1661
Years living in the area	0.0152	0.01	3.90	0.000	.0075	.0229
Gender (fem)	0.2956	0.11	2.49	0.014	.0614	.5298
Experienced Floods	0.5284	0.21	2.51	0.013	.1142	.9425
Experienced landslides	-0.3217	0.15	-2.08	0.038	-.6256	-.0179
Informed by experience	-0.4669	0.41	-1.13	0.259	-1.2797	.3458
Informed by local population	-0.6229	0.43	-1.43	0.154	-1.4818	.2360
Registered for info. services	0.0170	0.10	0.16	0.876	-.1966	.2307
Knowledge of INEA system	-0.0075	0.13	-0.06	0.954	-0.2655	.2504
Part of a CD capacitation	-0.0570	0.19	-0.29	0.775	-.4487	.3347
Reforestation as best measure	0.1073	0.13	0.77	0.442	-.1668	.3814
Green areas importance	-0.0737	0.08	-0.84	0.403	-.2468	.0994

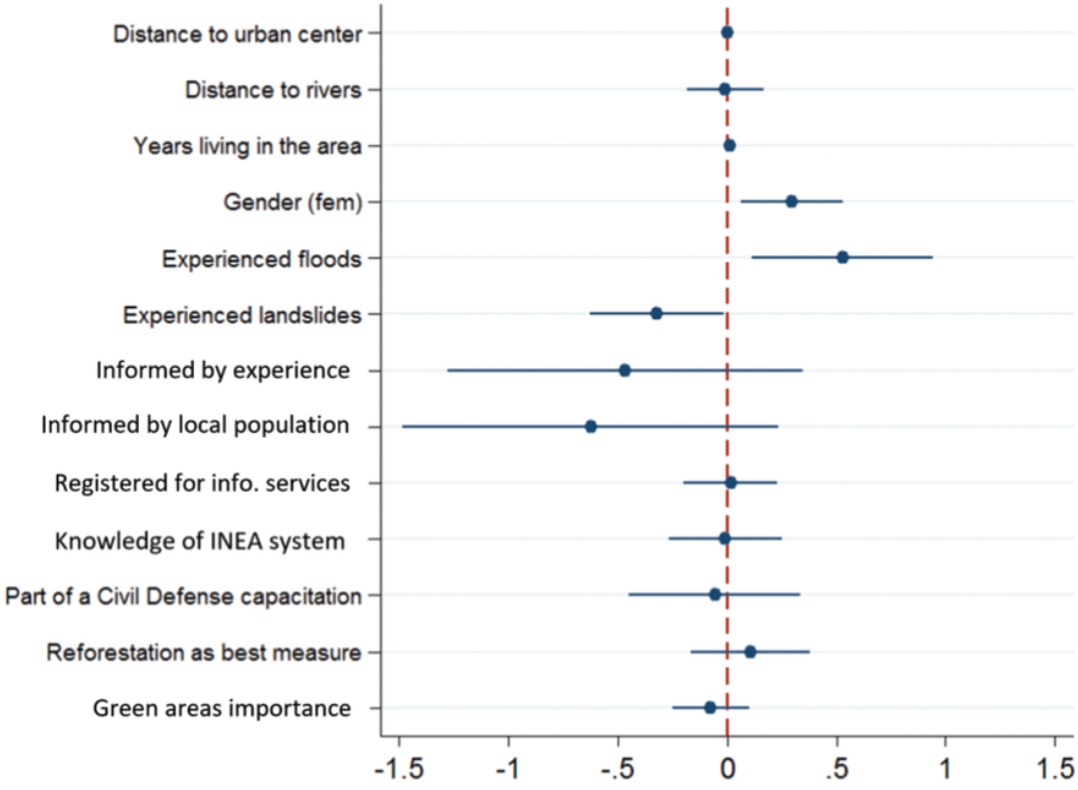

Fig. 3. Linear regression, independent variables coefficient plus confidence interval (flood risk perception as dependent variable). n = 302, R^2 = 0.34, Prob > F = 0.00.

ity of a further risk. The experience of landslides on the other hand, is negatively related to flood risk perception with a negative coefficient (coef. = −0.32). Those who experienced landslides perceived that there was less of a flood risk that may cause damage to their housing. This may be explained by the destruction caused by landslides compared to floods in 2011. In both cases, the result is clearly significant and relevant. The significant influence of previous experiences in risk perception and protective decisions is already mentioned in previous research [34–37].

Demographic variables such as gender (coef. = 0.29), age, years living in the area, communication facilities and income had more significance than location variables like closeness to urban centers (coef. = 0.01), rivers, roads and other facilities. The significance of gender variables is greater in countries where both legal and cultural differences between genders are stronger, like the case presented in Pakistan [38]. In the case of Brazil, without being extreme, gender plays an important role for FRP. Aspects of the possession of communication services such as telephone (coef. = 0.39) or internet (coef. = −0.30), are the most significant results. Age and years living in the area have a valid P > |t| value (under 0.1 and 0.05 respectively) but their coefficient is weaker (coef. = −0.01 and 0.01 respectively). In this context, people living longer in the area have more experience with past flood events and a slightly higher FRP (knowledge of historical floods effects, location of vulnerable places and vegetation around the area). On the other hand, age, having a negative coefficient, has an inverse relation to FRP. More research would be needed to explain this result. In the case of location variables, considering that all interviews were conducted with households close to rivers in neighboring areas, certain homogeneity is given in the sample. This homogeneity prevents geographical differentiation and more significance in the results. Also, there was a low relation of flood perception with factors of eco-DRR measures perception, such as the importance of green areas for risk prevention (coef. = -0.07) (coef = −0.07) and the role of reforestation in the surroundings (coef. = 0.10).

The variables of being part of the Civil Defense routine (P > |t| = 0.775; coef. = −0.05) or being linked to public information services (P > |t| = 0.876; coef. = −0.01) do not seem to have a significant correlation to FRP. Local influence and information coming from neighbors, family and friends (P > |t| = 0.154; coef. = −0.62) have, in this case, more relevance than institutional influence. During the interviews, many were able to give better examples of effective prevention measures taken by neighbors and families, than public institution recommendations. Risk perception was mainly based on a comparison with the neighbors. In RG a dweller argued: "it doesn't matter if institutions give us a map showing that this is a risk area, as long as other people are also living here, it can't be that dangerous". Among the reasons for this difference, there are arguments that there is mistrust in the government in terms of how data is created, the intentions behind the information given and the lack of presence of the institutions in specific areas and at a constant rate. In other words, legitimization, as Tierney [28] argues. This is a crucial point, because from all the measured variables, influence from public institutions and influence from neighbors, friends and family are variables that are easier to create, work on and change. While it is difficult to create or change risk experiences, it is possible to create spaces for IM exchange or improve public power influences.

3.2. Perception of hard intervention measures

Out of all the individual hard IM, the most extreme to be taken by population living in risk areas is to move to a safer area. Relocation as an adaptation solution creates many controversies [39], such as socio-spatial incompatibilities [40] and the search for optimal programs for relocation [41]. In this case, relocation is not an easy task considering that more than 70% of the Municipality of Nova Friburgo is under severe risk [42]. Even with the knowledge that they are living in a risk area, moving out is not a priority for the population; 43% of the total surveyed population thinks there is a necessity to move out, but only 23.8% are in some way in the process of moving out. Nevertheless, leaving the actual house after considering that it is under risk is only a solution for those who can afford it; 15.6% did not have the economic resources or the opportunity to move out. Only 5.8% had developed some kind of contention measure in order to improve their home's safety (Fig. 4).

The population located in official risk areas had to be relocated to the well-known "minha casa minha vida" federal relocation program. Working in 23 states, the program aims to enable house and apartment ownership to low income families. Although criticized for manipulating urban planning in order to liberate sub-used urban areas, by 2016 more than 4.6 million houses had been built. In the case of Nova Friburgo, the project "Terra Nova" was located close to Conselheiro Paulino, one of the largest neighborhoods north of the city. This comprised several buildings of seven blocks with 6–9 floors, each with between 2 and 4 flats with two rooms each. There were 2.337 benefited families planned for 2014, and until 2015, around 1.400 families were able to live in the flats [43]. From the 104 surveys in TN, 72 were households moved from risk areas in the last 2 years. More than half (52.7%) of the 72 surveyed people that had already moved to TN were very satisfied with the help received. Nevertheless, during deeper in-

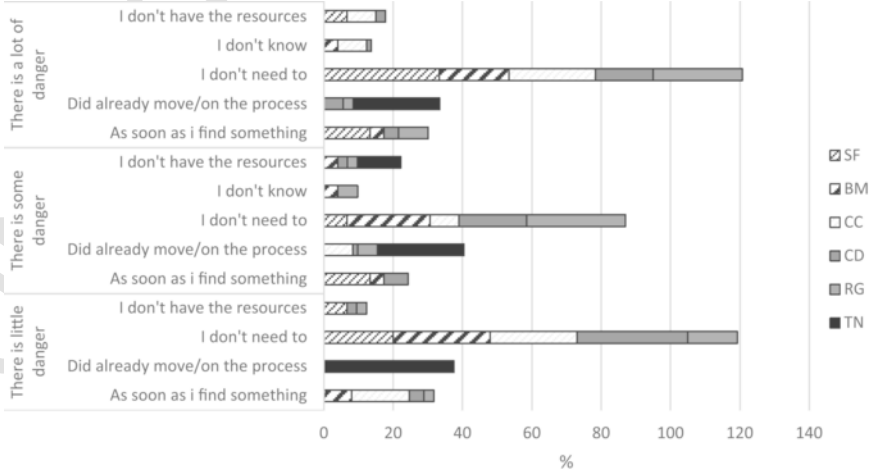

Fig. 4. Relocation intentions and possibilities of people perceiving some kind of danger (n = 167).

vestigation in the qualitative interviews, many problems were exposed. The developers are several years behind with the construction of services such as nurseries, schools and hospitals or clinics for the number of people residing there. Space was limited for average families requiring flats with more than two rooms. The population came from rural areas, most of them farmers, who had lost their livelihoods and were unable to produce anything in the small space received. Some people manifested their dissatisfaction in violence and dangerous gangs formed. These topics are in the agenda of local non-governmental institutions like INCID [44] and Viva Rio [45] and require further analysis. With this information, people still living in risk areas prefer to ensure their home is safe before accepting a move to resettlement neighborhoods, drastically changing their risk perception.

Perception of HIM is still highly rated as the best solution to reduce risk and is to be analyzed in both ways. Governments will prefer to invest in visible constructions and infrastructure to show progress. Local dwellers at the same time expect these types actions from the government; during interviews, phrases as "there is a channel being constructed along the river to reduce risk", or "the government should build more contention walls in order to reduce risk" were very common. In general, visible infrastructure counts as tangible projects for the government, because as a dweller argumented "they have a specific action, goal and construction time". Some 35.7% of the population, mostly in the peri-urban areas, put contention walls above reforestation and education for risk reduction (Fig. 5). People placing responsibility on institutions to take charge of risk reduction is to the detriment of the importance of actions of self-protection [46].

The advantages of ecosystem based adaptation measures (EbA) are increasingly becoming more evident, economically and functionally, in rural and also peri-urban areas [47,48]. Reforestation in the surrounding areas is either very important or relatively important for 91.8% of the population. Nevertheless 64.3% had never undertaken any kind of recovery or conservation action in or near their properties, and from the 35.7% who has done so, only 7.21% still do. A replantation or reforestation possibility is mostly limited to those living in the rural areas, since they could easily access some space on their property, garden or near the house. Also, actively planting trees privately is not a frequent practice, since by just avoiding "cleaning" an area (by cleaning, is referred to the action of cutting bushes and plants out), they perceived an automatic increase of bushes and threes. When giving three possible infrastructural solutions (dams, river channeling, and contention walls for landslides) and three non-infrastructural solutions (reforestation, education of risk areas and conservation of green areas) to risk reduction, reforestation and conservation was the best (or one of the best) measures perceived by only 31.6% of the population (Fig. 5). When ecological measures are mentioned, cleaning river banks is often suggested as a measure. Nevertheless, cleaning in this context refers to the extraction of trees, bushes and grass on the surroundings of the river rather than improving water quality.

3.3. Perception of soft intervention measures

Capacity building for risk warnings responses and knowledge on preparedness measures may define response efficacy. We have taken institutional strategies as variables to be measured as factors influencing people's perception. With regard to the production of institutional rearrangement [18], many dialogs and meetings had to be carried out in order to understand and agree on the internal functioning of the institutions. Along with this process, it was clear that despite the existence of relative clarity inside every institution, integration between the different institutions working on disaster risk reduction was needed. From the qualitative interviews held in 2015, it was also clear that the processes were not fully discussed with all agencies concerned and that capacity building was needed in order to fully understand technical information and further possible processes. Intra- and inter-institutional communication problems were cited three times as a missing point among the ten stakeholders working in the different institutions who were interviewed.

Although the Civil Defense reaches more population in Nova Friburgo than in any other municipality after RJ, the actual knowledge of the population about current strategies, instruments and contingency plans is limited. As presented in Table 3, the role of institutions in flood perception has to be improved in terms of trust, communication channels and language in order to reach a greater number of the population. The strategies developed are low in impact in the population interviewed, nevertheless there are many emerging alternatives being developed by NGOs and the organized population (Table 4).

Although most of the population has some kind of communication media at home (TV, radio, internet and/or telephone), most of the risk information is given by neighbors, family or direct observation. Although 81.89% of the interviewed population has access to cellphones, less than 25% of the population is registered with any kind of SMS information service. Some of those registered claim that messages are no longer sent and that information received is not exact or useful for their specific location. The online alert system of INEA depends on the internet, accessible for 42.43% of the population; 38.11% of the interviewed population knows something about the early warning system of INEA available online, nevertheless only 9.73% have accessed the web page at least once.

The communication channels are continuously diversifying: even though the institutions use sirens, SMS and web sites, the population

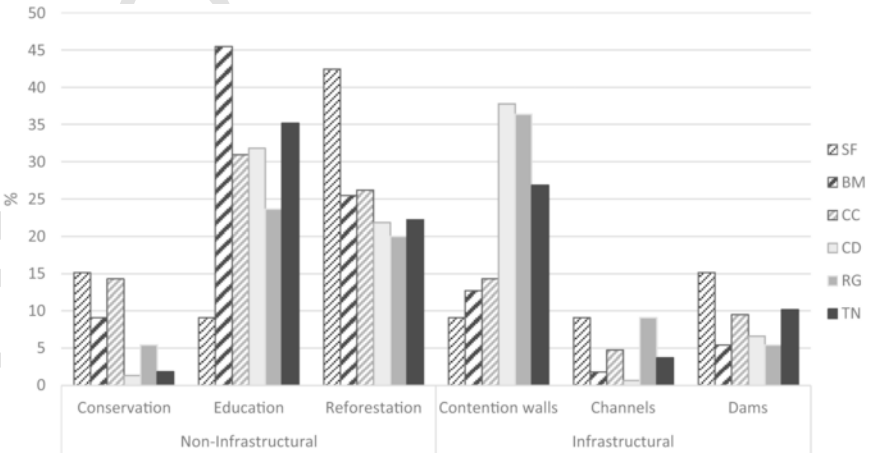

Fig. 5. Percentage of population per area perceiving a priority for DRR (n = 343).

Table 4
Institutional recognition, perception and local complementary strategies.

Institution	Strategy	Population (%)	Alternative population initiatives
INEA	Subscribed to INEA SMS alert system	4.05% (15)	Several social groups have been created (e.g. WhatsApp) for risk alert in specific areas (e.g. CD, RG, for the city center). In these groups, continuous information about the current situation in specific places is combined with official data.
	Knowledge of alert system website	38.11% (141)	Social media groups created by the organized population (e.g. Facebook group for risk and alert in NF) with direct access, warnings and comments about the official meteorological websites (INMET, INEA and CD).
	At least one visit to the website	9.73% (36)	
	Knowledge of the flood risk maps	15.95% (59) + possible 8.38% (31)	A community-based risk mapping was organized in 2012 by some NGOs in the most affected areas. Skills on mapping methodologies and the use of GPS were part of the project.
DRM	Knowledge of landslide risk maps	3.78% (14) + possible 8.38% (31)	The maps of DRM are created for the municipalities, focused on future planning. No direct access to the population.
Civil Defense	Subscribed to DC SMS alert system	18.11% (67)	Although this is the same system as INEA (first row), most of the population refers to the SMS system as the one from DC.
	Participation in capacity building courses	11.35% (42)	Courses and simulations have less attendance than expected, adding to the capacity building of the population, there are Red Cross groups doing risk reduction and first aid courses all year.
	Perception of sirens (very - little useful)	79.45% (290)	Many arguments against sirens because of false alarms and fear triggers, and the process following the alarms is not clear. Most of the surveyed people reacted to neighbors and family notifications and alerts in the lasts risk event
	Reaction to sirens (Frequently, always)	44.93% (164)	

always finds new channels and better ways to communicate or reach the community. Independent from the institutions, different groups in social media (such as WhatsApp and Facebook groups) are being created by local initiatives. These groups are constantly actualized by the population in different areas of the region, warning about the current situation in different neighborhoods, integrating and disseminating news of Civil Defense, the Red Cross, the firemen, INEA and the Climatologic Center amongst others. There are more than 17,300 members in a Facebook group for precipitation and flood alert just for Nova Friburgo, and diverse groups in WhatsApp according to specific regions. Although these methods reach more of the population due to their diversity and the associations by city and families, they are informal, prone to panic, unspecific in information quality and length, and disorganized. There are many opportunities for reaching the population and implementing new tools to solve problems like excess or false information, disorganization and panic creation.

The INEA risk maps were known only in the neighborhoods that had to be evacuated, since the relocation process was based on those maps. For instance, in Córrego Dantes, the population who refused to move out had a good knowledge of the risk maps. In some cases, they could highlight mistakes in the limitation of the risk areas based on their own experience. The methodology for the official risk maps was very difficult to track down. For the neighborhood Association in Córrego Dantes, it took more than a year to find a proper explanation of the methodology used for the risk maps.

The Civil Defense offers courses with evacuation routines and information in case of the activation of sirens in the city center of Nova Friburgo and in some other main neighborhoods. This course is given free, in public places and periodically to those who are interested, but among those interviewed, only 11.35% had taken it. The use of the sirens is considered to range from ‘a lot’ to ‘some’ use by 79.45% of the population, but 55.06% confessed that they never react to it, some argue: “we know that we have to go out when the alarm is issued, but we don’t know where to”. This fact supports Kellen's [34] theory that the term warning is not as important as the information content. Added to it, after many false alarms or failure to communicate simulations, trust has been diminished. A dweller in CC affirmed that “refuges installed by civil defense are extremely small for the population they intend to shelter and some of them are even located in unsafe places”. This may be the reason why more than half (54.32%) of the interviewed population would prefer to evacuate to family or friends’ houses located farther away from the river.

3.4. Influence of civil society on perception

After INEA declared Córrego Dantes as one of the most affected neighborhoods, a river park and a preserved area was proposed in this neighborhood. All families living in the risk area are to be relocated to Terra Nova and their houses demolished for the park. As soon as the proposal became official, local groups started to organize, gather information about regulations, information sources and the methodologies used for the risk maps. More than four years later, they created links and agreements with the Faculty of Geography of the UFRJ (Rio de Janeiro Federal University), investigation teams with Embrapa and ONGs working on risk like Viva Rio and Fiocruz. Nowadays, they have a strong information network, leading integrated research in the area, and have constructed a communal center with funds from the Swiss government. This is an example of organization and communication at local level. The perception of the local population in this area was clearly bigger in terms of local map knowledge, participation in courses, knowledge of the local surroundings and communication networks.

Many of the people interviewed discard the probability of another catastrophe like 2011 on the basis that the drought is ongoing. The current drought affecting the entire state is now a federal concern. In the rural areas, producers declared that they have been trying to dig water wells deeper and four of them declared that they had even lost springs in their territories. The farmers in CC meet once a month to discuss the situation, obtain information and search for alternatives and processes

to reach solutions. During the meeting one ensured that "there is a state program now, bringing technologies to get access to quality groundwater".

Responses related to non-protective measures were also considered. In particular, these included fatalism, wishful thinking and hopelessness related to religion. In Brazil, only 8% of the population consider themselves to be not religious and 89% are either catholic, evangelic or spiritualist [49]. Answers such as, "whatever God's will is, it will happen" in CD or "whenever He wants to take me, it is because it is my time" in RG or "it is not possible to know the intentions of the Lord" in BM were mentioned when people were asked about their private precautionary measures. A limitation on the analysis on religion is given, since this was not a variable in the questionnaires. The numbers attending churches and ritual centers increased in NF due to the trauma caused after 2011, and "the need of support after the loss of beloved ones" as a dweller in TN explained. The awareness of their inability to control events as Rotter explains [50], plays a significant role that can be further analyzed. Surviving the incident of 2011 meant for many of them that nothing worse could happen, if they and their houses survived the worse event in the history of the place, then they could survive anything.

Considering these examples, the interest and participation of the community is essential in order to continuously seek information and be aware of the changing environment. Even when risk reductions programs can play an important role in affecting risk perception [51], the importance of considering civil societies influence is evident. Constant innovation and dynamism in the implementation of private mitigation measures is driven by the population. There is a great deal of potential for the institutions, who could add some of these capacities into their programs.

4. Conclusions

In this paper explored the most influential variables for FRP and the interrelation of factors influencing DRP. From the six factors analyzed, flood risk perception is principally influenced by past experiences and demographic factors, followed by civil society and the influence of public institutions, respectively. This work focused on the analysis of civil society and public institutions' influence since those are factors that can be worked on, changed and therefore improved. According to the questionnaires taken, most of the population takes no part in the programs, courses or information networks offered by public institutions. Despite limitations on deeper analysis on discourse and social networks we relate this fact to communication methodologies, mistrust and skepticism, as the participation of institutions working in risk reduction has diminished in recent years. In the area studied, civil society's influence is clearly stronger; reasons such as communication channels, language and credibility were analyzed with specific examples.

Trust among dwellers is stronger in neighborhoods where representatives or population organizations are continuously working and exchanging information. Although power is clearly dictated by specific people in charge, associations are strongly linked to research projects, universities and even political parties. We evaluated the determinant variables defining perceptions of specific hard and soft intervention measures taken by the population and the influence of public institutions. HIM are generally perceived as the best solutions for disaster risk reduction among civil society and public institution members due to visibility and clear starting and ending points. SIM related to communication on response and evacuations require more work to reach more of the population. Alternatives to specific soft IM being further developed by civil society initiatives were described and analyzed.

Climatic processes and consequences are dynamic and require constant adaptation of institutions and society. Technologies, tendencies and even changes in events, such as the gradual drought in the state, require constant renewal of approaches, both in the measures and perceptions of all stakeholders. The interest and participation of the civil society is essential in order to cope with dynamism; create and expand information and simultaneously educate and build awareness of the ongoing local problems. Since the influence of the organized population is greater than the influence of the institutions in this case, there is a great potential for institutions to work with the organized elements of society and on issues such as social capital. Future research should focus on long term interactions and communication mechanisms between public institutions and civil society to improve perception and management. These mechanisms should be related not only to one specific risk, but should include various aspects of local interest. Including civil society and creating sufficient geographical and temporal spaces for information and experience exchange, could significantly improve communication, knowledge, perception and management of the stakeholders.

Conflicts of interest

None.

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Appendix A. Supplementary material

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.ijdrr.2017.09.006.

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