

Extreme Weather Events and its Socioeconomic Impacts: The City of Nina Rodrigues, Brazil case study ¹

Vicente Manzione Filho ²

Climate change and its consequences: increased in frequency and intensity of extreme weather events

For the IPCC - Intergovernmental Climate Change Panel, the costs and benefits of climate change on human settlements and society will vary widely depending on the location and scale. In aggregate, however, liquid effects will tend to be more negative the larger climate change. Human settlements and most vulnerable societies are generally those located in flood plains and coastal rivers, those whose economies are closely linked with climate-sensitive resources and those in areas prone to extreme weather events, especially where it is occurring faster urbanization.

Poor communities can be especially vulnerable, particularly those concentrated in high risk areas, such as areas of permanent preservation for example. They usually have more limited adaptive capacity and are more dependent on climate-sensitive resources, such as local food and water. In places where extreme weather events become more intense and/or more frequent, the economic and social costs of these events will increase and those increases will be substantial in the most directly affected areas. The impacts of climate change spread from impacted areas and sectors directly to other areas and sectors through extensive and complex connections.

In its fourth report, IPCC (2007) has projected that the impacts of extreme rainfall will become more frequent in most areas of the planet. For example, in the sector of agriculture and forestry, impacts are destroying crops, causing soil erosion and inability to grow crops again. Regarding to water resources, there will be adverse effects on the quality and availability of surface water and groundwater in both urban and rural areas. Floods of landslides, in addition to deaths and injuries will also cause health impacts in terms of increased diseases, allergies and dermatitis. Regarding on the impacts on industry and human settlements, there is a projection of pressure and disruption in trade, transportation and urban infrastructure due to floods.

A Study of the Management Center for Strategic Studies (CGEE, (2008) states that in comparison to other developing countries, Brazil and Latin America are not, generally, in the group of countries or regions of the world most vulnerable to climate change. In this category are almost all the countries of Africa and southern Asia, in addition to small oceanic islands and the main vulnerabilities of these countries will take place this century (are already taking place at a certain measurement) due to access to water and susceptibility of flooding.

However, this does not make Brazil a "climate change-proof" country. Thus, the study continues, the key issue is the extent to which Brazil is vulnerable to climate change. The Brazilian economy is heavily dependent on natural renewable resources mainly through agriculture, hydropower, biofuels and Bioenergy, making it potentially vulnerable to climate change that may eventually reduce the use of renewable natural resources, both those currently used primarily as the future use of these and new sources of these resources.

Secondly, the study highlights that climate change, climate variability as well as current with its extremes, emphasize the social vulnerability of the poor, simply because they have structural difficulties to cope with them and increase their adaptive capacity. The development stage of the country still has huge social and regional inequality and over 50% of the population can be considered poor, making it particularly vulnerable

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² He is an economist with MSc in Environment and Development from LSE/UK and specialized in Education for Sustainability at Schumacher College/UK. He is assessor and lecturer at Methodist University of Sao Paulo Environmental Centre, founder of BARCA Institute (www.a-barca.org) and partner at Origami Sustainability Management Consulting (www.gestaorigami.com.br). Email: vicente.manzione@a-barca.org.

that projected climate change, especially the rural population in semi arid Northeast and the urban poor on the peripheries of Brazilian cities and coastal areas with low elevations.

Finally, the environmental and ecological aspect, considering the characteristic of our mega-diverse tropical country and the relatively small elasticity of adaptation of species of fauna and flora to abrupt environmental changes, we can infer that our biological heritage can be very vulnerable to changes climate. In short, the country may have significant environmental and socioeconomic vulnerability to climate change.

The study of CGEE (2008) indicates that although there are still uncertainties in global climate models, one of the projections is important with respect to the higher occurrence of extreme weather and intense events such as drought, dry spells, windstorms, severe storms, floods, etc. ., a warmer planet. The occurrence of extreme events and their associated grave consequences such as occurred in Brazil in recent years, illustrate the need for an adaptation strategy for the country. With the expected expansion in the increased frequency of extreme events, several sectors of economic activities will have to adapt. For example, the private construction of dams and major engineering works, once the period of recurrence of floods could be modified. More frequent floods negatively affect agriculture, including accelerating the loss of soil fertility. The question of the possible increase in extreme weather refers to the problem of vulnerability of populations and ecosystems to these changes. A good measure of the ability to adapt to potential future climate change is to see how people face the natural variability of current climate and past history.

At this point, the study says it is possible to distinguish a profound difference in response to climatic extremes and variability between developed and developing nations. As the periodic droughts in the region, the flooding, landslides on slopes in mountainous regions and metropolitan teach us, people's vulnerability to such extremes of the country is actually pretty high. With warmer weather, there will be more water vapor in the atmosphere and an acceleration of the hydrological cycle. This is one of the projections of climate change where there is enough confidence. The acceleration of the hydrological cycle implies increased frequency of severe storms and intense. Landslides on slopes, floods and floods caused by severe storms are two natural disasters responsible for large numbers of casualties in the country, primarily in metropolitan areas of Rio de Janeiro, Recife, Salvador and Belo Horizonte, and the Serra do Mar and Mantiqueira , including health impacts in terms of increased mortality, morbidity. The systems of civil defense and public health must therefore take into account that such disasters tend to become more frequent in the future if global warming continued.

Case Study

In July of 2010 a team of teachers and students of Methodist University of São Paulo participated in the activities of Operation Catirina - Rondon Project in the city of Nina Rodrigues / MA. The Rondon Project is an initiative developed and implemented by the Ministry of Defense, in partnership with the Department of Education's Higher Education Ministry of Education (MEC) and aims to bring students to different realities that make up the country, enabling their contact with poor communities in several locations. Thus, the Project Rondon guarantees, through experiences, greater insight and integrity to the knowledge produced in academia and its role in contemporary society by giving the participating universities to offer students the third base of the tripod teaching-research-extension.

Over the past three years the summers in Brazil have been characterized by heavy rains in several regions. In December 2008 for example, the region of Vale do Itajaí was destroyed, cities were flooded and communities buried , with damage estimated at \$ 1 billion. In the summer of 2009, the rainfall in Sao Paulo city caused the interruption of the communication services 190, preventing the flow of information between the community, firefighters and civil defense agencies. That same year, Northeastern states have also suffered the consequences of a rainfall above average. In 2010, cities in the states of Rio de Janeiro, Pernambuco and Alagoas came to be again victims of extreme precipitation.

For the National Secretariat of Civil Defense (SNDIC), this type of event is classified as a Natural Disaster Related to Increase Hydro Rainfall and Floods that are subdivided into: i. Floods or Gradual flooding; ii. Sudden floods or mudslides; iii. Flooding, or; iv. Coastal flooding caused by the sudden invasion of the sea.

According to a survey of SNDC, the heavy rains that fell in the State of Maranhao on the months of March, April and May 2009 affected 93 counties and a population of 245,159 people, leaving 49,188 of them homeless and 22,669 shelterless. In 53 municipalities, SNDC classified the natural disaster as "floods or flood gradual" and 40 municipalities as "sudden floods or mudslides." The main difference in terms of impacts on society is that in the first case the community and government have time to act, removal of people from risk areas for example. Moreover, in the second case the time for action is well reduced, increasing the probability of catastrophic consequences.

Physical and meteorological characteristics of the study area

The city of Nina Rodrigues / MA suffered the worst flood of its history in the months of April and May 2009 beating the one that occurred in the early 60s and mid 80s. Conversations with local residents indicated that floods and droughts are common in the region's history, but nothing like the flood that occurred that year which brought destruction and economic losses to the city. The video link below shows the dimension of the flood: <http://www.youtube.com/watch?v=X6xTcBw2emc>.

Nina Rodrigues city has a population a little over 10,000 inhabitants, and according to SNDC, 2,733 people, about 30% of the population, were affected in some way during the flood, which 333 of these, were made homeless and 89 shelterless.

The disaster can be classified as an extreme weather event because of the dimension it had to the city population as well as the volume of rain that fell in the region. Figure 1 shows historical data of rainfall in the cities of Nina Rodrigues, Chapadinha Vargem Grande obtained by measurements of rainfall stations located in the region and managed by the National Water Agency since 1965.

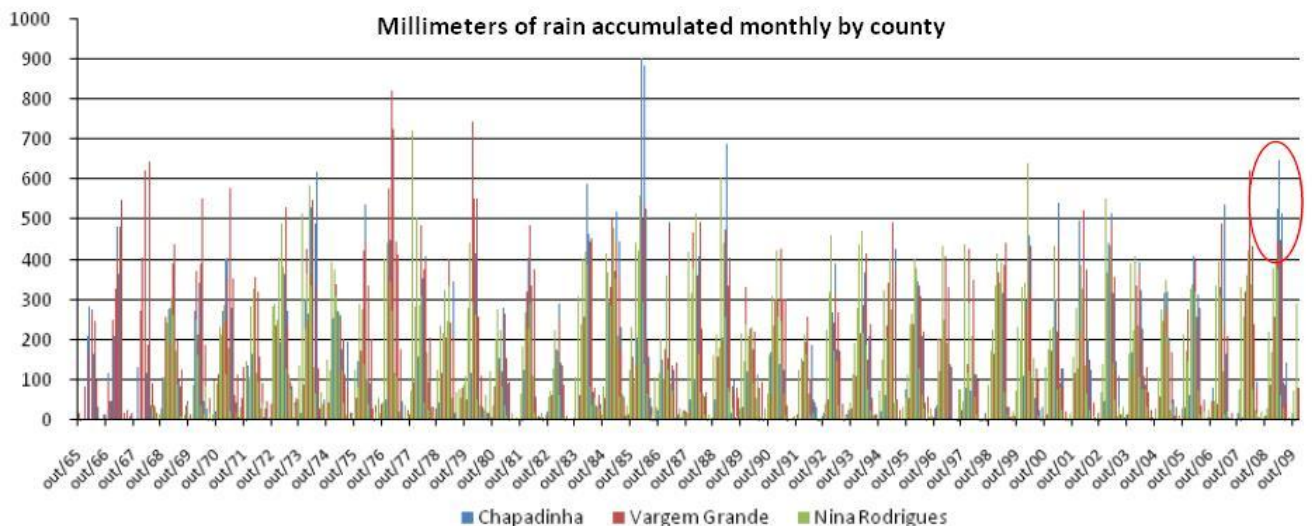


Figure 1

Source: Own elaboration with data from <http://hidroweb.ana.gov.br>

Figure 1 shows that in March, April and May 2009, the accumulated rainfall in the city of Chapadinha were respectively 529.6 mm, 648.5 mm (higher blue line in the red circle) and 515.3 mm. In the locality of Vargem Grande the accumulated rainfall was 450.7 mm, 450.9 mm and 430.7 mm respectively in the same period.

Rainfall in April 2009 in Chapadinha was the fourth largest in the history of the region getting only below the occurred in March and April 1986 and April 1989 when it rained a monthly cumulative volume of 904 mm, 886 mm and 690 mm respectively.

Table 1 shows that in the months analyzed, rained much above the historical average, with highlights for the months of April and May when it rained respectively 117% and 135% above the historical average for those months in the city of Chapadinha.

Table 1 - Percentage change of precipitation in 2009 over the historical average

Months	Historical Average 1968-2010	April 2009	Variation %
Chapadinha			
Mar	352,1	529,6	50,4%
Apr	298,7	648,5	117,1%
May	219,3	515,3	134,9%
Vargem Grande			
Mar	386,5	450,7	16,6%
Apr	354,9	450,9	27,1%
May	252,5	430,7	70,6%
Nina Rodrigues			
Mar	340,9	381,9	12,0%
Apr	314,9	398,8	26,6%
May	196,7	376,9	91,6%

Source: Own elaboration with data from <http://hidroweb.ana.gov.br>

The city of Nina Rodrigues is located at the confluence of Iguará and Munim Rivers. The first one flows through the municipalities of Chapadinha and Nina Rodrigues and the second one mostly through the city of Vargem Grande. Munim River is the main water body in the region and accordingly the Watershed Basin takes its name. Figure 2 below illustrates this situation.

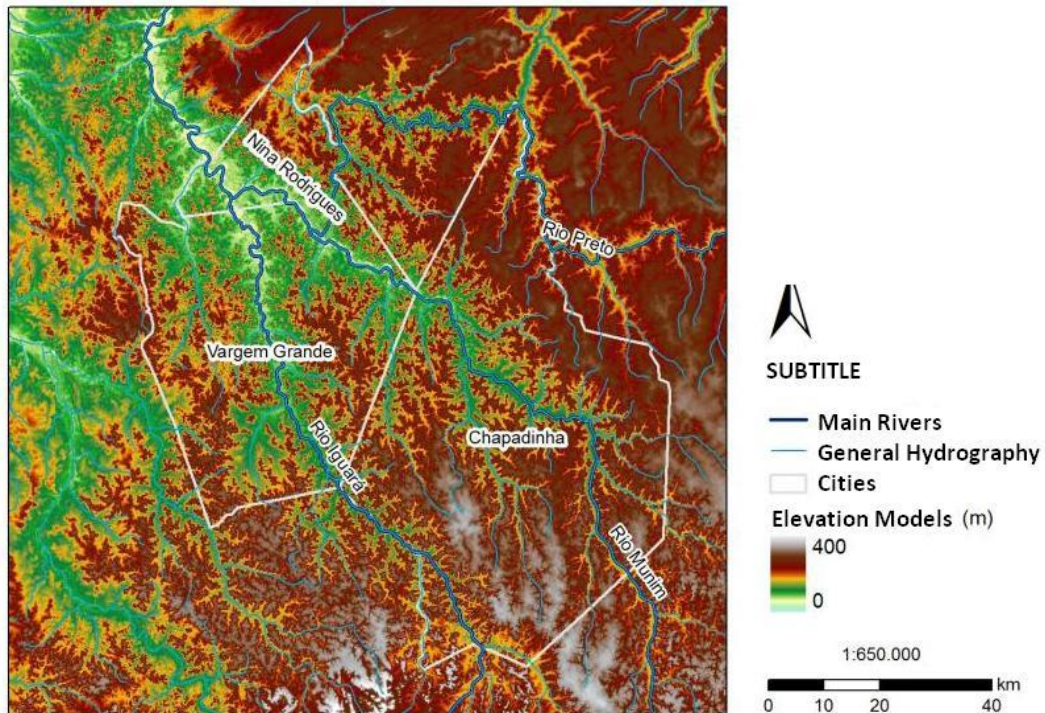


Figure 2 - Confluence of Iguará and Munim Rivers in Nina Rodrigues city

Although the spring of the Munim River is not localized in Chapadinha, that's where are located most of its tributaries as can be seen in Figure 3. The exceptionally high volume of rain in the city during the months analyzed had a major influence on the flood at Nina Rodrigues. However, only the volume of rain does not explain the severity of the flood.

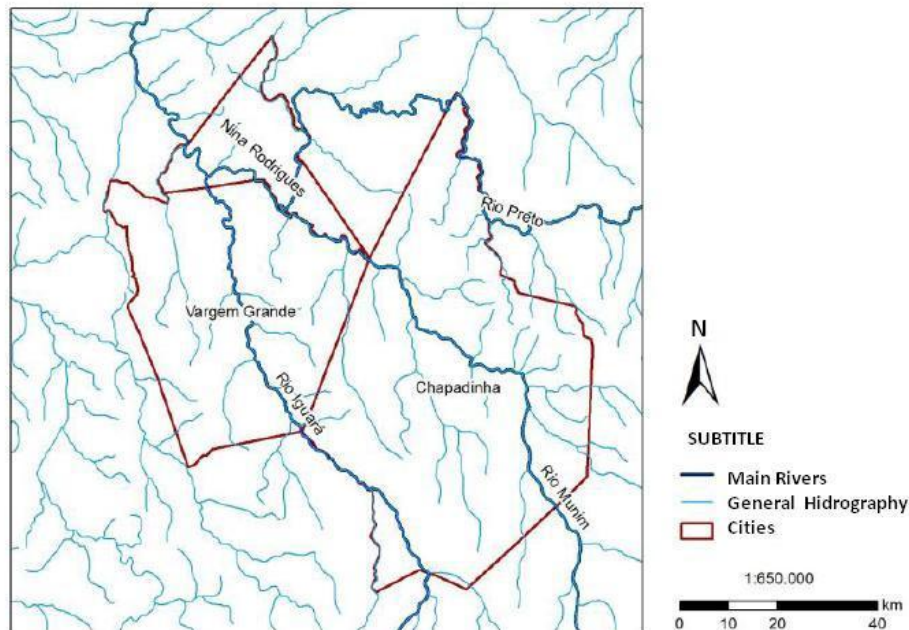


Figure 3 - General hydrography of the analyzed region and the tributaries of the Munim River in Chapadinha.

The urban densification of Nina Rodrigues happened in the area of the floodplain of the Munim River at low elevations and in areas of permanent preservation, as shown in figures 4 and 5. This feature maximized the effect of abnormal rainfall in 2009 contributing to the worsening of the consequences of rising river levels.

This is a characteristic of natural disasters in general around the world: the human interference, when ignoring the physical variables of the environment, tends to increase the effects of an extreme event.

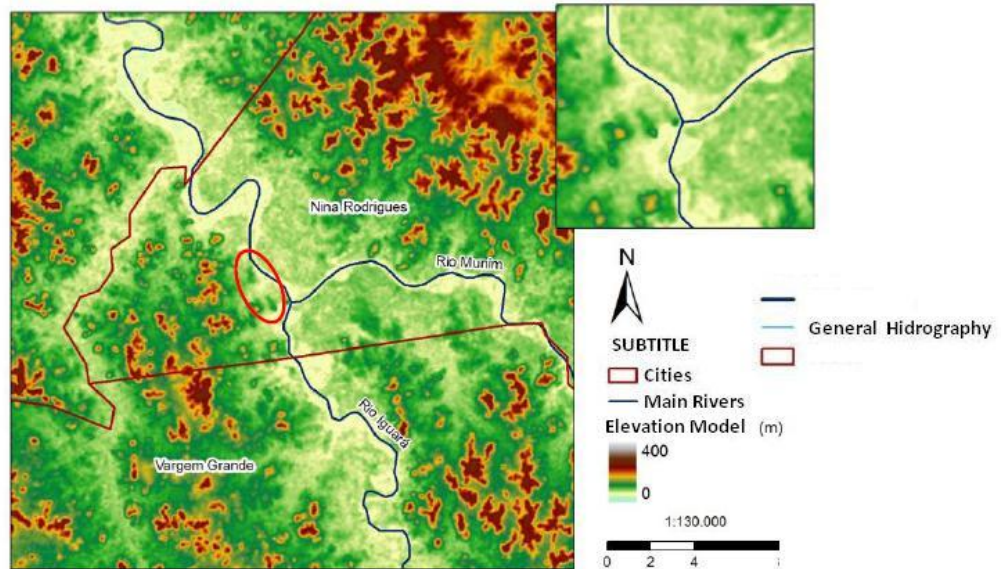


Figure 4 - Terrain characteristics at Nina Rodrigues. Red circles represent the flooded area in 2009.



Figure 5 - Satellite image of the urban area at Nina Rodrigues.

Source: Google Earth. Accessed 09/05/2010.

Populations' perception and impacts on community

One of the actions planned by Project Rondon in the city was the development of an activity about the environmental perception of the community, which would be applied in a structured questionnaire to survey this perception. Because of the flood that occurred the year before, it was decided to add some specific questions to treat this issue.

Thus, following a methodology by the United Nations Development Programme (UNDP) presented in the Assessment Guide to Reducing Vulnerabilities to Extreme Weather Events, we applied an adapted questionnaire including the following questions:

1. What happens when there is flood/drought? How it affects you or your community?
2. What if the severe flood / droughts were twice more often? How it would affect you or your community?

3. What are the barriers that must be overcome to adapt the city to an increase in frequency and intensity of flood / drought?

4. Which means you and your community have to manage flood / droughts events more frequent?

There were administered 41 questionnaires to teachers, schools' coordinators and students of the Pro-Jovem Program, employees of the Open University of Brazil and participants of the City Environmental Perception workshop. The last part of the paper describes the rationale behind each question as described in the applied methodology, and analyses the results of the questionnaire in graphs and tables.

The first question treats the aspects of development related to the present climate, usually the principal weather concern of the community. Table 2 shows the answers given by respondents in the questionnaire.

Table 2. Answers to the question: What happens when there is flood / drought? How it affects you or your community?

Replies	#	%
Homeless / bordering houses destroyed	27	40,3
Increased diseases	9	13,4
Quantity of food Reduced	16	23,9
Quantity of potable water Reducing	4	6,0
Flooding	1	1,5
Affects mentally / psychologically	1	1,5
Accumulation of garbage	2	3,0
Deaths	4	6,0
Slip / erosion	2	3,0
Affects Work / economy affects	1	1,5

Figure 6 shows the responses grouped in the table above: impacts on society, feeding, health and waste accumulation. It appears that society suffers the greatest impact on material terms, but the impacts on food and health are not negligible, corresponding to 30% and 21% respectively.

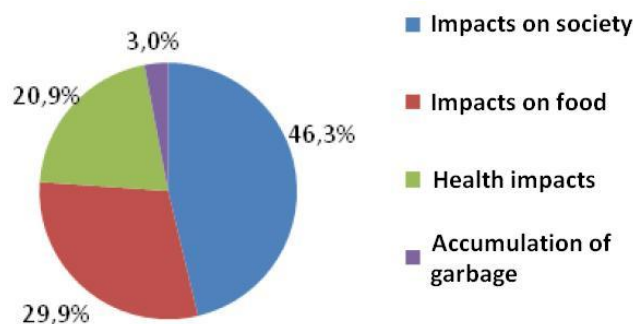


Figure 6. Answers to the question 1 grouped into categories.

The logic of the second question is to focus on community perceptions about the possible impacts of climate change, allowing the community to begin to consider the viability of your practice of living in a climate change scenario in the long term. The answers are presented in Table 3 and Figure 7 with the same grouping of the previous figure.

Table 3. Answers to the question: What would happen if the severe floods / droughts were twice more often? How it affects you or your community?

Replies	#	%
Change my place of residence	1	2,9%
Homeless	11	32,4%
Less food	10	29,4%
Less Potable water	3	8,8%
Diseases	5	14,7%
Deaths	4	11,8%

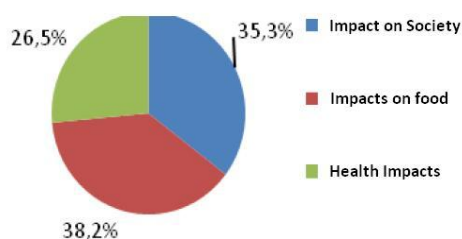


Figure 7. Answers to the question 2 grouped into categories.

The public perception in this case indicates that in the hypothesis of extreme events occur more frequently, the impacts on health and nutrition increased 6.1 and 8.3 percentage points respectively when compared with the answers to the first question.

The third question qualifies the indicators above, and focuses on community needs to adapt successfully. Moreover, the indicator also identifies practical and relating barriers to public policy, forming useful lessons for adaptation programs locally and nationally.

Table 4. Answers to the question: What are the barriers that must be overcome to adapt the city to an increase in frequency and intensity of flood / drought?

Replies	#	%
Lack of geographical study	1	2,4%
No transfer of irregular housing	10	23,8%
No ban on removal of sand / sedimentation	5	11,9%
Deforestation / Pollution	11	26,2%
Lack of national civil defense	1	2,4%
Lack awareness of local population	5	11,9%
Lack of infrastructure (bridges, barriers, engineer planner)	6	14,3%
Lack of commitment of public managers	2	4,8%
Many barriers	1	2,4%

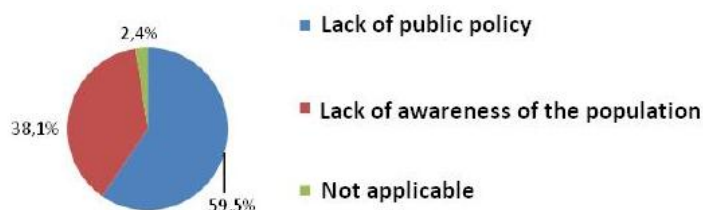


Figure 8. Answers to the question 3 grouped into categories.

Answers were grouped as follows: in Lack of Public Policy item are included the following answers: lack geographical study, the irregular housing not being transferred, lack of prohibition of sand removal / sedimentation, lack of civil defense organization, lack of infrastructure (bridges, barriers, engineer planner) and lack of commitment from public managers. In the item Lack of Lack of Awareness of the Population in sub-items were included: avoiding deforestation / pollution, and lack consciousness of the population living along the river.

The two main barriers are associated with the use and occupation of land; illegal housing and logging are two features that enhance the consequences of extreme natural events associated with intense rainfall.

The last question is designed to measure the community perceptions regarding their ability to continue the process of adapting to long-term.

The answers in blank represented 32% what was interpreted as the question was not understood because some people asked the meaning of "which means you and your ..." while answering the questionnaire.

Table 5 - Answers to the question: Which means you and your community have to manage flood events / more frequent droughts?

Replies	#	%
Shelters for the homeless	1	2,4%
Population orientation	9	22,0%
Convene civil defense	2	4,9%
Population Volunteers	5	12,2%
Distribution of food baskets	3	7,3%
Water supply	2	4,9%
Municipal government	3	7,3%
Convene fire station / entities	2	4,8%
Convene secretariat for social action	1	2,4%
No answer	13	31,7%

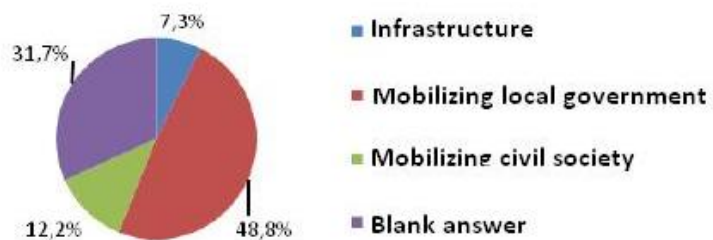


Figure 9. Answers to the fourth question grouped into categories.

The means the community has for adapt itself, or the answers given to the fourth question, were classified as follows: Infrastructure: shelters for the homeless and water supply. In item Mobilizing Local Government are included the sub-items: orientation to population; summon entities, food baskets distribution, municipal government, summon the fire station and the social action secretariat. In the item Civil Society Mobilization following sub-items are included: seeking civil defense and population volunteers.

Draws attention to the perception of the community that is responsibility of the government to provide the means for adaptation, since almost 50% of responses are directly related to this point. This is hardly

surprising since most of the socio-economy part of Nina Rodrigues city depends directly or indirectly on the city hall.

Recommendations to the city of Nina Rodrigues

The following recommendations as well as the results of the survey were included in the Environmental Plan left at Nina Rodrigues city hall at the end of the 15 days of activities in the city. Firstly we recommend the establishment of a direct communication channel with the municipalities located in the springs of Munin, Iguará and Black rivers, especially with the municipalities of Chapadinha and Vargem Grande, to allow the city to be prepared in advance in cases of intense rainfall volumes in these counties. The communication should preferably be maintained on a periodic basis by a trained civil defense city official.

Secondly, the city must perform a mapping of the vulnerable areas and elaborate the Master Plan of the city to prevent the occupation of EPA (Environmental Preservation Area) and risk areas as well as work towards the removal of residents and businesses in these areas. Important to consider in the planning of land occupation the maximum overflow of the river in 2009.

Finally, campaigns of public awareness of the risks of building in areas of permanent preservation should be frequent, especially in areas that are vulnerable to extreme weather events such as flood plains of rivers.

References

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