



Analysis of rainfall triggering mass movements in Angra dos Reis – RJ

Análise da pluviometria deflagradora de movimentos de massa em Angra dos Reis – RJ

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1 INTRODUCTION

One of the ways to reduce risks related to mass movements is to improve warning systems that use rainfall data to estimate the probability of one or more mass movements causing damage. Technical surveys carried out by DRM-RJ (2015) in the municipality of Angra dos Reis, indicated that a representative portion of the residences were in areas with soil susceptible to the occurrence of mass movements. Data from IBGE (2018) show that the municipality of Angra dos Reis had in 2010, 39% of the population living in areas considered at risk (related to mass movements and floods). Given this scenario, the public authorities have great difficulty in improving existing conditions or even relocating homes to safe areas in a short period of time. This situation indicates the need to improve the monitoring and warning systems of mass movement-related disasters in order to reduce the losses caused by disasters.

2 METHODOLOGY

This is research developed from the analysis of the records of the Inventory of Mass Movements of Angra dos Reis (LEAL et al. 2022a and 2022b), which has been built from the mapping of mass movement scars in satellite images available in the Google Earth Pro program, in addition to the records of mass movement occurrences of the Angra dos Reis Civil Protection and Defense Secretariat (SPDC) and the DRM (2015). With the analysis of the inventory time series (between 2001 and 2022), four events of great



relevance in the municipality were defined, three in 2010, 2013 and 2022, where the occurrence of mass movements was widespread and one in 2002, which despite not being possible to identify many scars, due to lack of data, the losses to the population were very expressive.

The rainfall data used were from the São Bento Station, at the Civil Defense of Angra dos Reis (manual rain gauge) for the 2002, 2010 and 2013 events and from Cemaden's Monsuaba Station (330010012A) for the 2022 event.

3 RESULTS AND DISCUSSION

Research developed from the choice of four events that strongly impacted the Municipality of Angra dos Reis and had great social appeal, these being the 8th and 9th of 2002, the turn of the year between 2009 and 2010, the 3rd and 4th of January 2013 and on April 2, 2022.

Each of the events were described based on SPDC Occurrence Records, CEMADEN-RJ data and newspaper reports. The description of the events is presented below:

1 - December 8 and 9, 2002.

The event of 12/09/2002 affected the Areal neighborhood, Banqueta, Ribeira, Belém and Nova Angra. Although there is still no precise record of the number of landslides, the event generated great losses for the municipality, including 34 fatalities. The event was publicized by the media (MONKEN and ESCÓSSIA, 2002) and the municipal government decreed a state of public calamity (ANGRA DOS REIS, 2002).

2 - Turn of the year between 2009 and 2010

Great calamity with many mass movements occurred in the municipality, two of which, one in Morro da Carioca and another in Praia do Bananal, on Ilha Grande, killed 53 people, in addition to many other damages caused. The State of Public Calamity was decreed by the mayor of Angra (ANGRA DOS REIS, 2010).

3 - Days 3 and 4 of January 2013

On January 3 and 4, 2013, heavy rains were related to the occurrence of more than a hundred landslides in the municipality of Angra dos Reis, in the upper course of some tributaries of the Jacuecanga River, upstream of the Caputera II neighborhood, landslides deposited large volumes of sediments in the waterways, generating a flow of debris that over approximately 4 km eroded the river banks, up to a Petrobras dam, where the sediments were deposited.

4 - April 2, 2022

On April 2, 2022, after an expressive accumulation of rain (JANSEN, 2022), a large number of landslides occurred in the eastern portion of the mainland of the municipality and west of Ilha Grande, generating many damages, including 11 fatalities in the Monsuaba neighborhood and three missing persons at Itaguaçu



Beach, on Ilha Grande. After the occurrence of landslides, many of them involving damage to the population, the municipality declared a State of Emergency (ANGRA DOS REIS, 2022).

- Information on the location, date and typology of the landslides was extracted from the events listed. Table 01 indicates the typology of mass movements and the most affected areas in each event.

Table 01 - Mass movements in Angra dos Reis A preliminary assessment of the rainfall data was carried out and it was observed that the rains preceding the mass movements started at least 72 h before the first occurrences. accumulated rainfall in 72 h prior to each of the events.

Event	Typology of mass movements	Most affected areas
1 - 08 a 09/12/2002	Translational Landslides and Debris Flows	Areal, Banqueta, Ribeira, Belém, Nova Angra, and Parque Perequê.
2 - 31/12/2009 a 01/01/2010	Translational landslides	Carioca and Bananal Beach
3 - 03 a 04/01/2013	Translational Landslides and Debris Flows	Caputera II, Santa Rita do Bracuí, Japuiba and lambicada.
4 - 01/04/2022	Translational landslides	Monsuaba and Itaguaçu Beach (Ilha Grande)

Source: MAGALHÃES (2023).

Evaluating the data in Table 02, it was observed that event 1 was triggered with a rainfall index greater than 280 mm and the others, events 2, 3 and 4 had rainfall accumulations greater than 400 mm in 72 h. The data from the rain gauge used for the evaluation of event 1 will be discarded because it is equipment installed at a point very far from the occurrence.

Rainfall accumulations	1 - 08 a 09/12/2002		2 - 31/12/2009 a 01/01/2010		3 - 03 a 04/01/2013		4 - 01/04/2022	
	Day	mm	Day	mm	Day	mm	Day	mm
24 h	07/12/02	0,0	30/12/09	140,0	02/01/13	206,0	31/03/22	7,3
48 h	08/12/02	9,6	31/12/09	244,0	03/01/13	473,5	01/04/22	409,8
72 h	09/12/02	284,6	01/01/10	415,0	04/01/13	504,6	02/04/22	702,8

4 CONCLUSION/FINAL CONSIDERATIONS

Preliminary results indicate that the widespread mass movement events analyzed in events 2, 3 and 4 occurred after rainfall accumulations of 400 mm in 72h. This is a first indication of a rainfall value to be considered for extreme events related to mass movements in Angra dos Reis. Other accumulated rainfall intervals will also be analyzed. The methodologies already applied to analyze this relationship in the municipality will be surveyed to evaluate the methodological possibilities and/or update the analyses already carried out.

The continuation of this study should also consider soil and urban occupation indicators for greater accuracy of the warning system, as these are important characteristics that influence the occurrence of mass movements.



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