

Unusual rainfall intensity and total amount causing more than 200 deaths in Petrópolis C

reports corresponds to a severely-affected neighborhood or street. Some photos presented in these reports are shown in Figure 2.

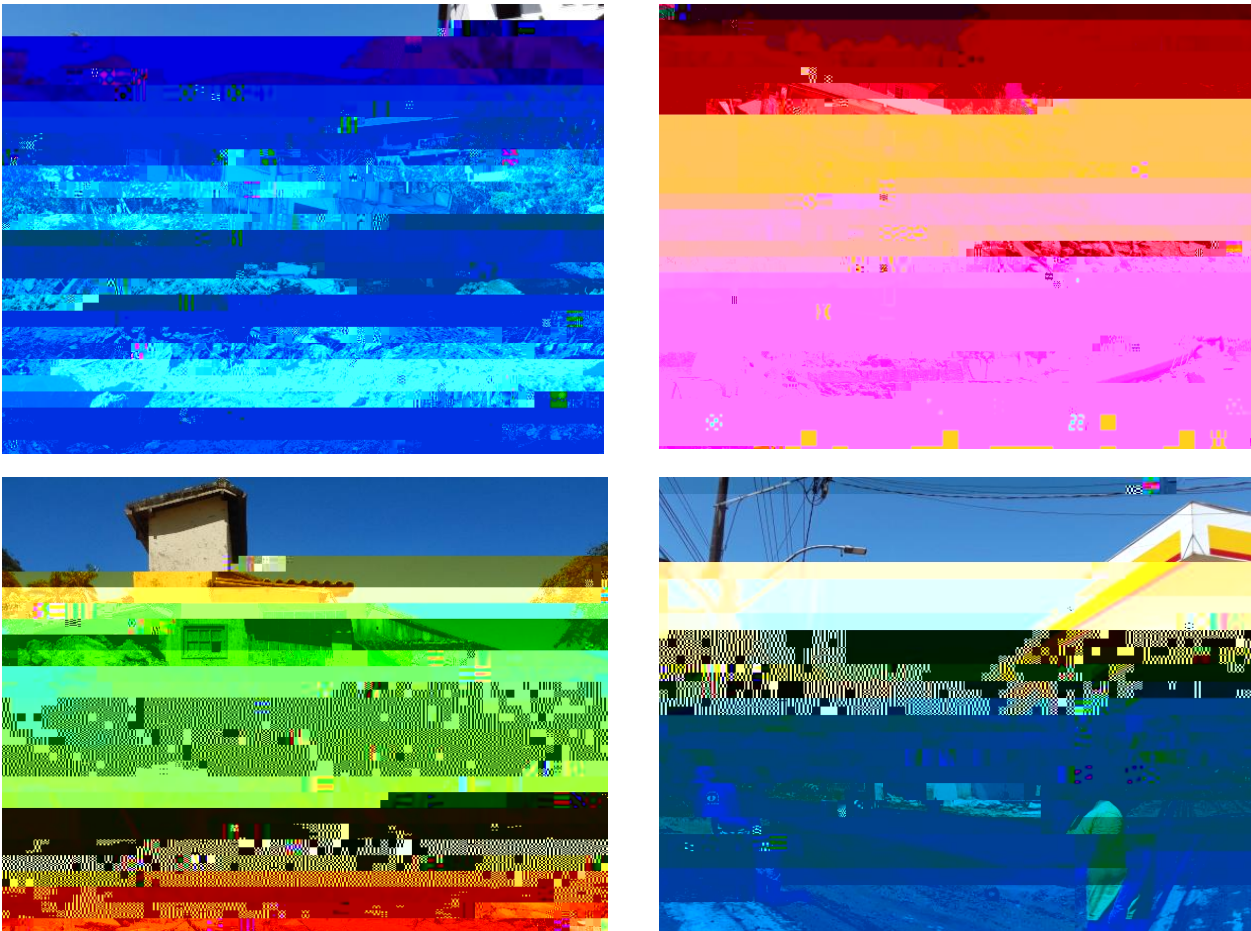


Figure 2 – Several localities of hydrological disasters in Petrópolis, Rio de Janeiro, Brazil (Sources: Modesto et al., 2022)

The social element associated to residents' vulnerability and exposure further intensified this tragedy. At the moment of a certain survey performed in 2012, Petrópolis City had 500 hazard areas. The evolution of the number of hazard areas and exposed people has been greatly intensified due to the large population growth as well as the lack of territorial control in the city. Therefore, in 2022, the numbers of hazard areas and highly-vulnerable population could be much higher. Such population growth results from the fact that Petrópolis belongs to the Metropolitan region of Rio de Janeiro and has many tourist spots.

Most of all places where disasters occurred are located at the foot of the steep hillslopes (Figure 1) and characterized with precarious land-occupations. There is no good infrastructure in these places, where, without projects approved by the city hall, residents have been carrying out self-constructions. This actual situation makes the areas even more fragile. Such a land-occupation's style can be considered typical both in Brazil and in Petrópolis and is becoming common more and more. In other words, these areas have turned into shantytowns (or slums), i.e., 'favelaizations' (Müller, 2017). Thus, hazard areas have been occupied by a poor population with no other choice.

Furthermore, as a part of the metropolitan region, Petrópolis has been exercising typical (or conventional) urbanization without adequate land-planning. In this city, there is a strong tendency to reduce river channel width for construction of roads and buildings, which certainly reduce river's transport capacity. Vegetation areas have been also decreasing. Urbanized areas without planning should seek for ecosystem services and/or ruralization proposed by Kobiyama et al. (2021).

According to Xavier (2022), the administrative movement for regularization of residences demonstrated the seriousness' lack in the housing policies of the city hall. In 2017, the Municipal Risk Reduction Plan had already indicated that more than 28,000 houses were in high or very high hazard areas which represented one

difficulty in predicting rainfall in mountain regions results from the poor investment for monitoring system, rainfall-induced disasters in Brazil might become social disasters indeed.

As Daré (2022) criticized the public policies in the city by mentioning frequent occurrences of tragedy, Petrópolis is well-known as a city frequently suffering from hydrological disasters. In the mountain region of Rio de Janeiro State, on January 11th, 2011, intense rainfall (281.6 mm in eight hours in Nova Friburgo) caused a historic tragedy, where 947 deaths, nearly 300 disappearances, more than 50 thousand homeless, affecting nearly 1 million people were reported (Dourado et al., 2012). Petrópolis was one of three most damaged cities in this tragedy. Table 1 shows the history of hydrological disasters with the number of victims recorded by the Civil Defense of Petrópolis during the period 1966 to

