GC Revista Nacional de Gerenciamento de Cidades
National Journal of City Management

ISSN 2318-8472, v. 12, n. 86, 2024

Climate Crisis and Human Health: The Case of Rio Grande do Sul

Leta Vieira de Sousa
Master in Smart and Sustainable Cities, UNINOVE, Brasil.
leta.vieira@gmail.com

Ana Vitória Wernke
PhD in Architecture and Urbanism, Universidade Presbiteriana Mackenzie, Brasil.
ana.wernke@gmail.com

Tatiana Tucunduva Philippi Cortese
Professor in the Graduate Program in Smart and Sustainable Cities, UNINOVE, Brasil.
tatianatpc@uni9.pro.br

GC Revista Nacional de Gerenciamento de Cidades
National Journal of City Management

ISSN 2318-8472, v. 12, n. 86, 2024

ABSTRACT
The World Health Organization (WHO, 2021) estimates that climate change already results in more than 150,000 annual deaths, with projections expected to increase in the coming decades. This is a multidimensional risk that requires strategic interventions. Therefore, this article, based on disasters that occurred in Rio Grande do Sul in 2024, aims to contribute to the understanding of the impacts of climate change on health.

KEYWORDS: Climate change. Rio Grande do Sul. Health.

1 INTRODUCTION

The climate crisis has intensified relentlessly. The records of this crisis's impacts in Brazil from 2022 to 2024 are alarming. In February 2022, Petrópolis (RJ) was devastated by torrential rains, causing floods, landslides, and over 230 deaths. Simultaneously, the State of Rio Grande do Sul suffered from a historic drought, harming agricultural production and the economy. Hailstorms and strong winds also impacted the southern region of the country.

In February 2023, the northern coast of São Paulo State was hit by heavy rains, resulting in floods, landslides, and over 60 deaths in cities such as Guarujá and Bertioga. Meanwhile, extreme drought in Amazonas State affected riverside communities and biodiversity, with the death of more than 140 dolphins due to rising water temperatures. The Pantanal also experienced one of the worst years in its history, with fires devastating flora and fauna (G1, 2023).

More recently, in March 2024, the Southeast was struck by a severe storm, causing flooding, inundations, and landslides in metropolitan areas like São Paulo and Rio de Janeiro. Record-breaking rains led to material damage, loss of life, and disruptions for the population, including power outages in some regions.

Between April 27 and May 2, 2024, it was Rio Grande do Sul's turn once again. The state made headlines across the country due to climate-related disasters. This time, it was not drought but heavy rains. In just a few days, between 500 mm and 700 mm of rain fell, equivalent to one-third of the annual average. This event resulted in landslides, dam collapses, and flooding in various cities. The population barely had time to recover. On May 10, the northern half of Rio Grande do Sul saw the rivers Jacuí, Taquari, Antas, Caí, Sinos, Paranhana, and Gravataí turn into seas. In addition to the rains, two tornadoes were recorded on May 11, one in Gentil and another in Cambará do Sul, causing severe material damage (G1, 2024).

On May 23-24, rains reached nearly 200 mm in the Vale do Rio Pardo, between 80 and 130 mm in the northern state, and nearly 150 mm in the Porto Alegre region. These continuous events resulted in significant flooding and widespread inundations, heavily impacting local infrastructure and the population (G1, 2024).

The climate disasters in Rio Grande do Sul between April and May 2024 resulted in 169 deaths, 44 missing persons, and an estimated 2,347,664 people affected by landslides, dam collapses, and flooding caused by the inundations.

These numbers represent the direct victims of the climate event. However, waterborne diseases, such as leptospirosis, may affect these same victims or bring new ones.

ISSN 2318-8472, v. 12, n. 86, 2024

Regarding leptospirosis alone, the increase was significant: 76 confirmed cases and 4 deaths (G1, 2024). The future outlook suggests a rise in disease cases due to the high number of human and animal deaths. Additionally, the force of the water tore through and broke containment barriers in industries and rural properties, releasing toxic substances into the environment.

Pesticides, fertilizers, and other industrial chemicals were identified in preliminary water analyses, posing a risk to human health and the ecosystem. This contamination may affect the quality of drinking water, food production, and local biodiversity (FANTÁSTICO, 2024). Consequently, the response to the 2024 disasters in Rio Grande do Sul must go beyond rebuilding urban infrastructure and cities. It must also focus on strengthening public health and its resilience and adaptation to the impacts of climate change.

This article aims to analyze the impacts of this climate tragedy on public health in Rio Grande do Sul and explore how the State can enhance its resilience and adaptation.

2 CLIMATE CRISES

Climate change involves long-term alterations in temperature patterns and other climatic indicators, which may be natural or caused by human activities, resulting in increased global average temperatures, rising sea levels, and intensified extreme weather events. The academic consensus attributes a crucial role to the Industrial Revolution in accelerating these changes, primarily due to the burning of fossil fuels, which increases greenhouse gas emissions (IPCC, 2013).

Greenhouse gases, such as CO_2, CH_4, and N_2O, originating from fossil fuel combustion, deforestation, and industrial agriculture, intensify the greenhouse effect, driving global warming. The consequences of this warming are extensive and impact health, food security, biodiversity, water resources, agriculture, the economy, and infrastructure (IPCC, 2013). The 2021 IPCC report confirms human influence on global warming, predicting a continuous rise in temperatures until mid-century, exceeding the goals of the Paris Agreement unless there are drastic emission reductions (IPCC, 2021).

The IPCC (2021) warns that extreme weather events are becoming more frequent and intense in many parts of the world, a trend corroborated by the WMO, which noted a fivefold increase in the number of reported extreme climate events globally since 1950 (WMO, 2023). In the field of human health, the World Health Organization (WHO, 2022) warns that climate change is a major threat, causing deaths and diseases due to extreme weather events, vector-borne diseases, and food insecurity. The Lancet Countdown (2023) highlights that climate changes have already caused more than 150,000 deaths per year, with a trend of increasing in the coming decades.

Understanding these dimensions is essential for developing effective public policies and adaptation actions aimed at reducing risks and increasing the resilience of communities and natural systems (IPCC, 2014).

Oh et al. (2017) emphasize that the climate exposure index is a crucial factor in health vulnerability to climate change, significantly affecting the health and well-being of people exposed to extreme events. Regional differences in exposure can be moderated through social investments in infrastructure, healthcare, climate risk information dissemination, and

ISSN 2318-8472, v. 12, n. 86, 2024

community capacity building to face these challenges. Strengthening community resilience can thus minimize negative health consequences and promote sustainable development, also addressing the social, economic, and political consequences of climate change (UNEP, 2021).

3 IMPACT OF CLIMATE CHANGE ON HEALTH IN RIO GRANDE DO SUL

As observed, climate change has significant implications for human health, with effects that exceed the current capacity of epidemiology to distinguish its direct impacts from other causes. Keune et al. (2012) state that the science of health effects related to climate changes is emerging, requiring further studies to better understand these complex interactions. The World Health Organization (WHO, 2021) estimates that climate change already results in more than 150,000 deaths annually, with projections of an increase in this number in the coming decades. According to Md Iqbal Kabir et al. (2016), the health risk due to climate change is multidimensional and requires strategic community interventions, especially in developing countries.

Keune et al. (2012) and Turner (2022) highlight the importance of transdisciplinary approaches to solving sustainability issues and implementing adaptive health strategies, which include environmental protection, improved basic sanitation, adequate housing, and appropriate land use. Sustainable and healthy territories are essential for regional and local development, where community actions and public policies intersect. The creation of healthy cities, which improve both the physical and social environment, strengthens community resources and enhances quality of life (Barcellos, 2008; MMA, 2016; Confalonieri, 2008).

The health perspective can integrate various policies, such as environmental, health, urban planning, and economic development, which are crucial for supporting policies to combat climate change. However, integration between science and policy at the municipal level is still inadequate, requiring more attention to align scientific knowledge with local political practice (Keune et al., 2012). In the Global South, particularly in Brazilian metropolises, the historical fragility of public housing policies has led to marginal occupations in peripheral areas and favelas, exacerbating socio-environmental vulnerability. In the case of Porto Alegre, this condition is compounded by the establishment of human settlements in buffer areas, such as those along the banks of the Taquari River.

.

GC Revista Nacional de Gerenciamento de Cidades
National Journal of City Management

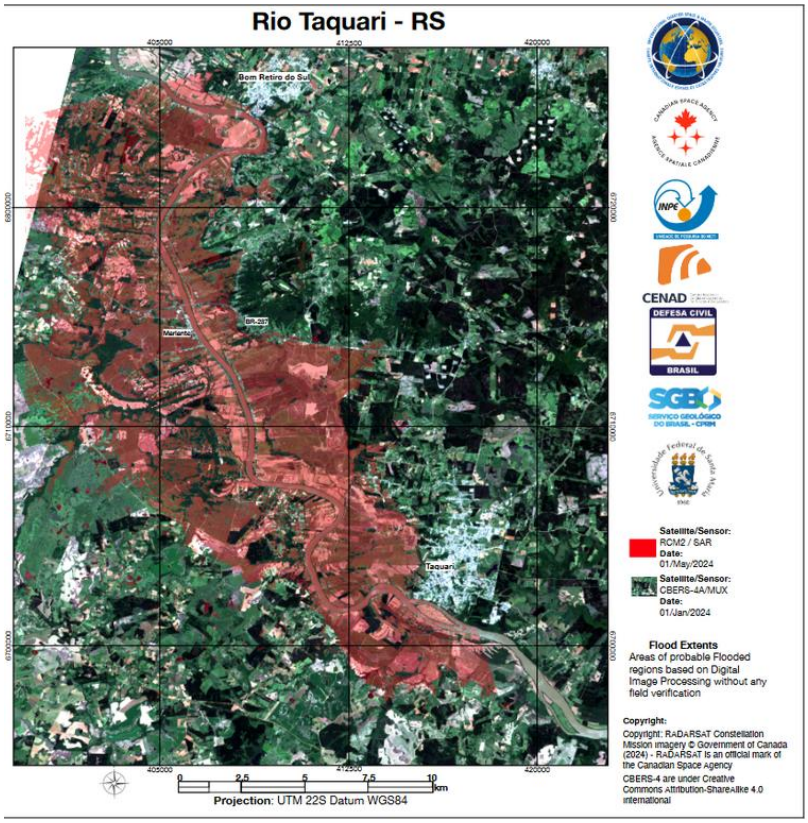
ISSN 2318-8472, v. 12, n. 86, 2024

Image 1- Satellite image taken on April 6 shows the region of Porto Alegre, in Rio Grande do Sul, submerged by the flood.

Source: European Union/Copernicus Sentinel-2 via Reuters (https://g1.globo.com/rs/rio-grande-do-sul/noticia/2024/06/02/ruas-e-rodovias-atingidas-por-enchentes-no-rs-somam-distancia-suficiente-para-atravessar-brasil-de-norte-a-sul-ou-de-leste-a-oeste.ghtml)

Considering the tragedies in Rio Grande do Sul, the hydrological impacts (floods, inundations, and waterlogging) are analyzed.

Image 2 - Satellite image reveals the extent of flooding in the Taquari Valley in Rio Grande do Sul



Source: DIOTG/INPE https://www.gov.br/mcti/pt-br/acompanhe-o-mcti/noticias/2024/05/imagem-de-satelite-revela-extensao-da-inundacao-no-vale-do-taquari-no-rio-grande-do-sul

ISSN 2318-8472, v. 12, n. 86, 2024

Climate change is intensifying water-related extreme events, such as increased evaporation and glacier melting, resulting in more intense rains and frequent floods (Nobre & Marquetti, 2015). Sea level rise also contributes to the risk of coastal flooding, threatening densely populated areas and critical infrastructure (Nobre et al., 2016). Butler et al. (2019) highlight that record storms have impacted developing countries differently, exacerbated by factors such as geographical location, soil conditions, and population vulnerability.

The terms "flood," "inundation," and "waterlogging," though often used interchangeably, refer to distinct events. A flood is the overflow of a watercourse due to heavy rains or glacier melting, inundating adjacent areas (Nobre et al., 2018). Waterlogging results from the accumulation of water in urban or rural areas due to drainage system failures or channel blockages, exacerbated by soil impermeabilization and unplanned occupation (Nobre, 2019; Nobre et al., 2021). Inundation occurs in low-lying or poorly drained areas, usually due to soil saturation or overflow of smaller rivers, and is more frequent and less severe than floods (Nobre, 2016; Nobre et al., 2020).

Despite being different phenomena, floods, inundations, and waterlogging have similar impacts on human health. Among their direct effects on human health, the following stand out:

- Physical trauma: cuts, fractures, injuries from submerged objects, and drownings are the main physical traumas caused by floods. Strong currents can carry people and objects, resulting in severe injuries and deaths (WHO, 2018). Drownings, the primary cause of death, occur in flowing or still water, even shallow, with risk influenced by age, swimming ability, and access to safety equipment (Jonkman et al., 2008);
- Infectious diseases: exposure to contaminated water during floods increases the risk of infectious diseases, such as leptospirosis, diarrhea, hepatitis A, and skin diseases (CDC, 2017). The proliferation of mosquitoes in flooded areas also raises the risk of diseases like dengue, malaria, and chikungunya (Ministry of Health, 2016);
- Respiratory problems: flooding of buildings can lead to mold and moisture accumulation, triggering or worsening respiratory problems such as asthma, bronchitis, and allergies. Exposure to mold and fungi present in contaminated water can also cause pneumonia and other lung infections (MS, 2016);
- Food poisoning: flooding can contaminate food and drinking water sources, leading to ingestion of pathogens and toxins. Diarrhea, vomiting, and dehydration are common symptoms (Fewtrell & Kay, 2005);
- Chemical exposure: flooding can release hazardous substances present in chemicals, pesticides, and building materials, causing poisonings and long-term health issues (Fewtrell et al., 2005);
- Compromised healthcare system: floods can damage or destroy health facilities, hinder access to medications and medical services, worsening pre-existing health conditions and complicating the management of chronic diseases (Bracken et al., 2010);
- Food insecurity: loss of crops and disruption of food supply chains can lead to malnutrition and food insecurity, especially in vulnerable populations (FAO, 2011);
- Mental health: floods can increase acute stress, PTSD, depression, and domestic violence. The loss of property, disruption of routine, and uncertainty about the

ISSN 2318-8472, v. 12, n. 86, 2024

future affect mental well-being, especially in individuals with a history of mental health issues. Stress and socioeconomic hardships elevate the risk of domestic violence, particularly against women and children (American Psychiatric Association, 2021).

4 IDENTIFIED CASE DETECTION IN RIO GRANDE DO SUL: LEPTOSPIROSIS

Leptospirosis is a zoonotic disease influenced by environmental factors such as rainfall and temperature, whose distribution and seasonality can be altered by climate change (Gubler et al., 2001). Floods can contaminate areas with rodent urine, the primary reservoirs of Leptospira, increasing the risk of infection for humans (Lau et al., 2010). Higher temperatures can expand the habitat and breeding season of rodents, resulting in larger populations and a greater risk of leptospirosis transmission (Mills et al., 2010). The combination of elevated temperatures and abundant rainfall favors the maintenance of the bacteria in soil and water, prolonging human exposure (Semenza & Menne, 2009).

The vulnerability of human populations to leptospirosis is exacerbated by socioeconomic and infrastructural factors, especially in low-income communities with inadequate sanitation.

Leptospirosis symptoms range from mild, flu-like manifestations to severe and potentially fatal forms. Initial symptoms include fever, headache, chills, muscle pain, vomiting, diarrhea, and conjunctivitis, complicating early diagnosis and proper treatment (Adler & de la Peña Moctezuma, 2010).

In severe cases, leptospirosis can progress to Weil's syndrome, characterized by jaundice, kidney failure, hemorrhages, and meningitis (McBride et al., 2005). Kidney failure is a common complication and can occur in up to 40% of severe cases, potentially requiring dialysis (Levett, 2001). Hemorrhages can range from minor mucosal bleeding to massive pulmonary hemorrhages, associated with high mortality rates (Gouveia et al., 2008). Neurological consequences include aseptic meningitis and meningoencephalitis, which may result in permanent cognitive and motor deficits, especially common in children (Panaphut et al., 2002). Leptospirosis can also cause uveitis, leading to significant vision loss if not properly treated (Mendes et al., 2012).

The impact of leptospirosis on public health is significant, particularly in urban and rural areas of tropical and subtropical countries where the disease is endemic (WHO, 2011). Underreporting and underdiagnosis hinder the implementation of effective control and prevention measures (Haake & Levett, 2015). The morbidity and mortality associated with leptospirosis represent a considerable burden on healthcare systems, especially during outbreaks associated with floods and natural disasters (Ko et al., 2009). Prevention and control of leptospirosis require a multifaceted approach, including improvements in sanitation infrastructure, rodent control, health education, and epidemiological surveillance. Investments in research to develop effective vaccines are also essential to reduce the impact of this disease (Vinetz, 2001; Adler & de la Peña Moctezuma, 2010).

ISSN 2318-8472, v. 12, n. 86, 2024

5 CONCLUSION

The climate crisis has intensified considerably in recent years. Among the impacts of this crisis, which is strongly driven by human activity through greenhouse gas emissions, are extreme weather events such as the floods that struck the State of Rio Grande do Sul in the early months of 2024. This phenomenon was characterized by the concentration of rain in a single region due to an atmospheric blockage that caused weather systems to remain over Rio Grande do Sul instead of moving to other states. This blockage caused heat and humidity to settle in the State, leading storm clouds that would usually last a few hours to persist for several days, with an estimated increase in intensity of around 15%.

Clearly visible, the floods, inundations, and waterlogging bring with them not only the destruction of urban infrastructure and homes but also biological, pathogenic, and chemical agents that cause diseases in various forms. In the case analyzed in this article, there has been an increase in leptospirosis cases identified to date. However, the literature indicates that the occurrence of climate events can have several effects on public health, such as mental distress, food insecurity, and an impact on the healthcare system itself, either through the network being compromised by floods or by overcrowding in the case of tragedies. It is important to note that, as a highly productive state, food security issues may affect not only Rio Grande do Sul but also Brazil as a whole. It is no coincidence that the Federal Government has resorted to measures such as purchasing cereals like rice on the international market to avoid stock shortages and subsequent price increases.

Since this is a recent occurrence, the State of Rio Grande do Sul has yet to fully assess the impacts on public health and the incidence of diseases, which will certainly appear as the waters recede. Over time, the consequences of pesticide leaks, sewage pipe ruptures, contamination of groundwater, dead animals, and garbage accumulation will become apparent.

It is imperative, however, that analyses conducted in this process be undertaken through the lens of the climate crisis to integrate public policies related to urban planning, housing, health, and the environment. Only through this policy integration will cities be able to respond adequately to the health effects of the climate crisis. May the tragedy that occurred in the fall of 2024 in the lands of Rio Grande do Sul raise awareness not only for responding to climate tragedies but also for urban planning.

6 THEORETICAL FRAMEWORK

6.1 Books

AMERICAN PSYCHIATRIC ASSOCIATION. **The impact of climate change on mental health: A brief overview.** Washington, DC: American Psychiatric Association, 2021.

BANCO MUNDIAL. **Climate Change and Health.** Washington, DC: The World Bank, 2016.

CDC. **Water-related Diseases and Contaminants in Public Water Systems.** Atlanta: Centers for Disease Control and Prevention, 2017.

CDC. **Health Impacts of Disasters.** Atlanta: Centers for Disease Control and Prevention, 2021.

FAO. **The State of Food and Agriculture 2011**. Rome: Food and Agriculture Organization of the United Nations, 2011.

ISSN 2318-8472, v. 12, n. 86, 2024

FAO. **The State of Food and Agriculture 2016: Climate Change, Agriculture and Food Security.** Rome: Food and Agriculture Organization of the United Nations, 2016.

FAO. **The State of Food and Agriculture 2017: Leveraging Food Systems for Inclusive Rural Transformation.** Rome: Food and Agriculture Organization of the United Nations, 2017.

IPCC. **Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.** Cambridge: Cambridge University Press, 2013.

IPCC. **Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.** Cambridge: Cambridge University Press, 2014.

IPCC. **Climate Change 2018: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.** Cambridge: Cambridge University Press, 2018.

IPCC. **Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.** Cambridge: Cambridge University Press, 2021.

Schlosberg, David. **Defining Environmental Justice: Theories, Movements, and Nature.** Oxford University Press, 2007.

LANCET COUNTDOWN. **The Lancet Countdown on Health and Climate Change.** 2023 Report. Available at: https://www.thelancet.com/countdown-health-climate. Accessed on: 2 jun. 2024.

NOAA. National Oceanic and Atmospheric Administration. **Global and Regional Sea Level Rise Scenarios for the United States.** 2023. Available at: https://oceanservice.noaa.gov/hazards/sealevelrise/sealevelrise-tech-report.html. Accessed on: 2 jun. 2024.

MMA. Ministério do Meio Ambiente. **Política Nacional sobre Mudança do Clima.** 2016. Available: https://www.mma.gov.br/pol%C3%ADticas/publicacoes/item/7426-pol%C3%ADtica-nacional-sobre-mudan%C3%A7a-do-clima-pnmc.html. Accessed on: 2 jun. 2024.

MS. Ministério da Saúde. **Saúde Ambiental nas Emergências e Desastres.** Brasília: Ministério da Saúde, 2016.

OMS. Organização Mundial da Saúde. **Global Report on Drowning: Preventing a Leading Killer.** Geneva: World Health Organization, 2018.

SCHLOSBERG, D. **Defining Environmental Justice: Theories, Movements, and Nature.** Oxford: Oxford University Press, 2007.

UNEP. United Nations Environment Programme. **Emissions Gap Report 2021.** Nairobi: UNEP, 2021. Available at: https://www.unep.org/emissions-gap-report-2021. Accessed on: 2 jun. 2024.

WHO. **Ambient Air Pollution: A global assessment of exposure and burden of disease.** Geneva: World Health Organization, 2016.

WHO. **Climate Change and Health.** Geneva: World Health Organization, 2022. Available at: https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health. Accessed on: 2 jun. 2024.

WHO. **Guidelines for Drinking-water Quality.** Geneva: World Health Organization, 2010.

WHO. **Leptospirosis worldwide, 2011.** Geneva: World Health Organization, 2011.

WHO. **Mental health and climate change: Policy brief. Geneva**: World Health Organization, 2018.

WHO. **Protecting health from climate change: vulnerability and adaptation assessment.** Geneva: World Health Organization, 2014.

ISSN 2318-8472, v. 12, n. 86, 2024

WMO. World Meteorological Organization**. State of the Global Climate 2023.** Geneva: WMO, 2023. Available at: https://library.wmo.int/index.php?lvl=notice_display&id=22100. Accessed on: 2 jun. 2024.

6.2 Book chapter

BARCELLOS, C.; QUARESMA, P. C.; PEREIRA, A. L. Vulnerabilidade socioambiental: desafios para a promoção da saúde. In: **Saúde no Brasil: desafios para a promoção da saúde.** Ministério da Saúde, 2008. Available at: http://bvsms.saude.gov.br/bvs/publicacoes/saude_brasil_2008.pdf. Accessed on: 2 jun. 2024.

ASSOCIAÇÃO BRASILEIRA DE SAÚDE COLETIVA. Impacto das ondas de frio na saúde da população. In: **Relatório Anual de Saúde Coletiva.** Associação Brasileira de Saúde Coletiva, 2018. Available at: https://www.abrasco.org.br/site/publicacoes/relatorios/impacto-das-ondas-de-frio-na-saude-da-populacao/42541/. Accessed on: 2 jun. 2024.

FEWTRELL, L.; KAY, D. Health Impact Assessment for Sustainable Water Management. In: Fewtrell, L.; Kay, D. (Eds). **Water Quality: Guidelines, Standards and Health**. IWA Publishing, 2005.

6.3 Journal articles

ABRAHAMSON, V.; RAINE, R. Health and social care responses to the Department of Health Heatwave Plan. **Journal of Public Health**, v. 38, n. 4, p. 688-694, 2016.

ALVES, F.; MOREIRA, M. A emergência climática nas áreas urbanas. **Revista de Climatologia**, v. 12, n. 2, p. 189, 2017.

ASTELL-BURT, T.; FENG, X. Association of urban green space with mental health and general health among adults in Australia. **JAMA Network Open**, v. 2, n. 5, p. e198209, 2015.

BALAKRISHNAN, K.; DHALIWAL, R. S.; BRAUER, M.; JETTÉ, M. E.; PARK, J. W.; HENDERSON, S. B. Exposure to airborne particulate matter with emphasis on epidemiological evidence of its health effects. **Environmental Research Letters**, v. 8, n. 3, p. 034023, 2013.

ADLER, B.; DE LA PEÑA MOCTEZUMA, A. Leptospira and leptospirosis. **Veterinary Microbiology**, v. 140, n. 3-4, p. 287-296, 2010.

ADGER, W. N.; HUGHES, T. P.; FOLKE, C.; CARPENTER, S. R.; ROCKSTRÖM, J. Social-ecological resilience to coastal disasters. **Science**, v. 309, n. 5737, p. 1036-1039, 2005.

BELL, M. L.; GOLDBERG, R.; LEVY, J. I. The impact of air pollution on health. **The Lancet**, v. 370, n. 9591, p. 1903-1912, 2007.

BENDER, M. A.; KNUTSON, T. R.; TULEYA, R. E.; SIRUTIS, J. J.; VECCHI, G. A.; GARNER, S. T.; HELD, I. M. Modeled impact of anthropogenic warming on the frequency of intense Atlantic hurricanes. **Science**, v. 327, n. 5964, p. 454-458, 2010.

BÉNÉ, C.; WOOD, R. G.; NEWSHAM, A.; DAVIES, M. Resilience: New Utopia or New Tyranny? Reflection about the Potentials and Limits of the Concept of Resilience in Relation to Vulnerability Reduction Programmes. **IDS Working Paper**, v. 2012, n. 405, p. 1-61, 2012.

BLACK, R.; ADGER, W. N.; ARNELL, N. W.; DERCON, S.; GEDDES, A.; THOMAS, D. Climate change: Migration as adaptation. **Nature**, v. 478, n. 7370, p. 447-449, 2011.

BRACKEN, L. J.; WARBURTON, J.; BAIN, V. The impacts of flooding on health: New research perspectives. **Environmental Health**, v. 9, n. 1, p. 12, 2010.

BROOKS, N.; ADGER, W. N.; KELLY, P. M. The determinants of vulnerability and adaptive capacity at the national level and the implications for adaptation. **Global Environmental Change**, v. 15, n. 2, p. 151-163, 2005.

BROOK, R. D.; RAJAGOPALAN, S.; POPE, C. A.; BROOK, J. R.; BHATNAGAR, A.; DIEZ-ROUX, A. V.; KAUFMAN, J. D.; PARTI, K.; MIYAMOTO, Y.; ALIWALE, M.; HAYS, R. A. Particulate matter air pollution and cardiovascular disease: An update to the scientific statement from the American Heart Association. **Circulation**, v. 121, n. 21, p. 2331-2378, 2010.

BROWN, L.; MURRAY, V. Examining the relationship between infectious diseases and flooding in Europe. **Disaster Health**, v. 1, n. 2, p. 117-127, 2013.

ISSN 2318-8472, v. 12, n. 86, 2024

BUTLER, C. D.; HARVEYS, M. J.; BARRY, K. M. The climate change-health nexus: A critical review. **Environmental Research Letters**, v. 14, n. 7, p. 073002, 2019.

CARVALHO, J.; LIMA, V.; SILVA, R. Geological Mass Movements: Causes and Effects. **International Journal of Geosciences**, v. 5, n. 3, p. 234-245, 2014.

CHEN, H.; ZHOU, X.; HAN, T.; CHEN, Y.; JIANG, W.; LI, J.; XU, L. Air pollution and asthma: A case-crossover study in Beijing, China. **Environmental Health**, v. 16, n. 1, p. 71, 2017.

CLAYTON, S.; MANNING, C.; HODGE, C. Beyond storms & droughts: The psychological impacts of climate change. **American Psychological Association**, 2014.

COLWELL, R. R. Global climate and infectious disease: The cholera paradigm. **Science**, v. 274, n. 5295, p. 2025-2031, 1996.

CONFALONIERI, U. E. C. Climate change and human health: an assessment by a task group on behalf of the World Health Organization, the World Meteorological Organization, and the United Nations Environment Programme. **EcoHealth**, v. 5, n. 1, p. 3-8, 2008.

COSTA, J. E.; ARAÚJO, A. R. Movimentação de massa: conceitos e processos. **Revista Brasileira de Geociências**, v. 37, n. 2, p. 1-13, 2007.

CUTTER, S. L.; BARNES, L.; BERRY, M.; BURTON, C.; EVANS, E.; TATE, E.; WEBB, J. A place-based model for understanding community resilience to natural disasters. **Global Environmental Change**, v. 18, n. 4, p. 598-606, 2010.

DANNENBERG, A. L.; ROGERSON, B.; RUDOLPH, L. Optimizing the health benefits of climate change policies using health impact assessment. **Journal of Public Health Policy**, 2020. Available at: https://doi.org/10.1057/s41271-019-00189-y. Accessed on: 10 dez. 2023.

DAVIES-JONES, R.; TRAPP, R. J.; SCHULTZ, C. Severe convective storms and tornadoes: Observations and dynamics. **Meteorological Monographs**, v. 50, p. 167-221, 2009.

DUARTE, J. L.; DIAZ-QUIJANO, F. A.; BATISTA, A. C.; DUARTE, A. F.; MELCHIOR, L. A. K.; GIATTI, L. L. Variabilidade climática e internações por doenças diarreicas infecciosas em um município da Amazônia Ocidental brasileira. **Temas Livres**, p. 2959-2970, 2018. DOI: 10.1590/1413-81232018248.21232017. Accessed on: 6 dez 2023.

FERNANDEZ, A.; BLACK, J.; JONES, M.; WILSON, L.; SALTARELLI, K.; NICHOLLS, L.; AHERN, M. Flooding and mental health: **A systematic mapping review**. PLoS One, v. 10, n. 4, p. e0119929, 2015.

FERREIRA, V. Vulnerabilidade socioambiental nas metrópoles brasileiras: uma análise da precariedade urbana. **Cadernos Metrópole**, v. 9, n. 18, p. 21-40, 2007.

FOLKE, C.; CARPENTER, S. R.; WALKER, B.; SCHEFFER, M.; CHAPIN, T.; ROCKSTRÖM, J. Resilience thinking: Integrating resilience, adaptability and transformability. **Ecology and Society**, v. 15, n. 4, p. 20, 2010.

FÜSSEL, H. M.; KLEIN, R. J. T. Climate change vulnerability assessments: An evolution of conceptual thinking. **Climatic Change**, v. 75, n. 3, p. 301-329, 2006.

GALEA, S.; NANDI, A.; VLAHOV, D. The epidemiology of post-traumatic stress disorder after disasters. **Epidemiologic Reviews**, v. 27, n. 1, p. 78-91, 2005.

GOUVEIA, E. L.; METCALF, M.; FRASER, M.; HARRISON, A. L.; LEWIS, M. A. Leptospirosis-associated severe pulmonary hemorrhagic syndrome, Salvador, Brazil. **Emerging Infectious Diseases**, v. 14, n. 3, p. 505-508, 2008.

HAINES, A.; KOVATS, R. S.; CAMPBELL-LENDRUM, D.; CORVALAN, C. Climate change and human health: Impacts, vulnerability, and public health. **Public Health**, v. 120, n. 7, p. 585-596, 2006.

HAJAT, S.; VARDIYAKIAN, A.; HEAVISIDE, C.; BOSCHETTI, F.; EBI, K. L.; HAINES, A.; HOWDEN-CHAPMAN, P.; KOVATS, R. S. Climate change effects on human health: Projections of temperature-related mortality for the UK during the 2020s, 2050s and 2080s. **Journal of Epidemiology and Community Health**, v. 68, n. 7, p. 641-648, 2014.

HAKE, D. A.; LEVETT, P. N. Leptospirosis in humans. **Current Topics in Microbiology and Immunology**, v. 387, p. 65-97, 2015.

HANCOCK, T.; DUHL, L. Healthy cities: promoting health in the urban context. **World Health Organization Regional Office for Europe**, 1988.

HYNDMAN, D.; HYNDMAN, D. Natural Hazards and Disasters. **Belmont**: Brooks/Cole, 2010.

ISSN 2318-8472, v. 12, n. 86, 2024

JONKMAN, S. N.; MAASKANT, B.; BOSEMSCHUTZ, H.; SCHROPP, H. Flood risk assessment and management in the Netherlands. **Journal of Flood Risk Managemen**t, v. 1, n. 1, p. 1-9, 2008.

KABIR, M. I.; RAHMAN, M. B.; SMITH, W.; LUSHA, M. A. F.; MILTON, A. H. Climate change and health in Bangladesh: a baseline cross-sectional survey. **Glob Health Action**, 2016. Available at: http://dx.doi.org/10.3402/gha.v9.29609. Accessed on: 22 dez. 2023.

KEUNE, H.; LYON, P.; COOPER, M.; VANDERMEULEN, V.; PEREZ, P.; KOS, D. Transdisciplinary knowledge production in sustainability science: An analysis of an intergovernmental research institute. **Sustainability Science**, v. 7, n. 2, p. 115-126, 2012.

KEUNE, H.; LUDLOW, D.; VAN DEN HAZEL, P.; RANDALL, S.; BARTONOVA, A. A healthy turn in urban climate change policies; European city workshop proposes health indicators as policy integrators. **Environmental Health**, 2012. Available at: http://www.ehjournal.net/content/11/S1/S14. Accessed on: 10 dez. 2023.

KJELLSTROM, T.; HOLMER, I.; LEMKE, B. Workplace heat stress, health and productivity - an increasing challenge for low and middle-income countries during climate change. **Global Health Action**, v. 2, p. 2047-2972, 2009.

KNUTSON, T. R.; MCCARTHY, G.; COOKE, W. F. Climate change and extreme weather events. **Nature** Climate Change, v. 10, p. 446-452, 2020.

KO, A. I.; GOARANT, C.; PICARDEAU, M. Leptospira: The dawn of the molecular genetics era for an emerging zoonotic pathogen. **Nature Reviews Microbiology**, v. 7, n. 10, p. 736-747, 2009.

KONING, C.; LOOIJ, B.; SMIT, L. Contact dermatitis from soil contaminants: A case report**. Contact Dermatitis**, v. 75, n. 4, p. 235-238, 2016.

KRUEGER, J.; LAWTON, B. The Natural Environment as an Object of Public Health Law: Addressing Health Outcomes of Climate Change through Intersections with Environmental and Agricultural Law. **The Journal of Law, Medicine & Ethics**, 2020. Available at: https://doi.org/10.1177/1073110520979373. Accessed on: 13 dez. 2023.

LAU, C. L.; DOBSON, A. J.; TAYLOR-ROBINSON, A. W.; MARSHALL, A. J.; WEINSTEIN, P. L. Leptospirosis: An emerging disease in travellers. **Travel Medicine and Infectious Disease**, v. 8, n. 1, p. 33-39, 2010.

LEVETT, P. N. Leptospirosis. **Clinical Microbiology Reviews**, v. 14, n. 2, p. 296-326, 2001.

LIU, H. et al. Climate change and Aedes albopictus risks in China: current impact and future projection. **Infectious Diseases of Poverty**, 2023. Available at: https://doi.org/10.1186/s40249-023-01083-2. Accessed on: 6 dez 2023.

MD IQBAL KABIR, et al. Climate change and health in Bangladesh: a baseline cross-sectional survey**. The Lancet Planetary Health**, v. 1, n. 7, p. e240-e245, 2016.

MELO, E. A.; MAIA, A. G.; SOUZA, A. M.; SANTOS, M. A. Socioeconomic impacts of extreme weather events on health systems: A review. **International Journal of Environmental Research and Public Health**, v. 14, n. 11, p. 1337, 2017.

MENDES, F. M.; CASTRO, J. R.; NOGUEIRA, R. A. Uveitis associated with leptospirosis. **The Journal of Infection in Developing Countries**, v. 6, n. 3, p. 271-273, 2012.

MENDES, C. S.; COELHO, A. B.; FÉRES, J. G.; SOUZA, E. C.; CUNHA, D. A. Impacto das mudanças climáticas sobre a leishmaniose no Brasil. **Ciência & Saúde Coletiva**, 2015. DOI: 10.1590/1413-81232015211.03992015. p. 263-272. Accessed on: 10 dez. 2023.

MILLS, D.; SHERIDAN, S. C.; MEGAN, K. E.; ARMSTRONG, B.; LOOMIS, D.; NAUMOVA, E. N. Climate change and health: A review of the literature on heat-related morbidity and mortality. **Environmental Health Perspectives**, v. 118, n. 4, p. 541-549, 2010.

MILLS, J. N.; GOYAL, M.; HARLOW, J. K.; GERBER, S. I.; BROWN, M. J.; JENNINGS, W. G. Changes in environmental conditions and their impact on leptospirosis outbreaks in the tropics. **International Journal of Environmental Research and Public Health**, v. 7, n. 2, p. 666-677, 2010.

MODA, H. M.; FILHO, W. L.; MINHAS, A. Impacts of Climate Change on Outdoor Workers and Their Safety: Some Research Priorities. Int. J. **Environ. Res. Public Health**, 2019. Available at: https://doi.org/10.3390/ijerph16183458. Accessed on: 22 dez. 2023.

NAZIF-MUNOZ, J. I.; MARTÍNEZ, P.; WILLIAMS, A.; SPENGLER, J. The risks of warm nights and wet days in the context of climate change: assessing road safety outcomes in Boston, USA and Santo Domingo, Dominican Republic. **Injury Epidemiology**, 2021. Available at: https://doi.org/10.1186/s40621-021-00342-w. Accessed on: 22 dez. 2023.

ISSN 2318-8472, v. 12, n. 86, 2024

NOBRE, C. A.; MARQUETTI, A. P. Climate extremes and their impacts on water resources. Water Resources Research, v. 51, n. 7, p. 5153-5163, 2015.

NOBRE, C. A.; SANTOS, A. M.; LYRA, A. A. Coastal floods and sea level rise. **Journal of Coastal Research**, v. 32, n. 6, p. 1256-1262, 2016.

NOBRE, C. A.; CARVALHO, L. M. V.; CAVALCANTI, I. F. A. Floods in the Brazilian Amazon. **Journal of Hydrology**, v. 560, p. 357-371, 2018.

NOBRE, C. A. Urban floods and drainage systems: The role of city planning. **Urban Water Journal**, v. 16, n. 5, p. 356-367, 2019.

NOBRE, C. A.; COSTA, M. H.; OBREGON, G. Urban flooding and climate change: Analysis of risk areas in Brazilian cities. **Climate Risk Management**, v. 34, p. 100-112, 2021.

NOBRE, C. A.; ANDERSON, M.; MELO, R. Flood risk in low-lying areas: Implications for urban planning. **International Journal of Disaster Risk Reduction**, v. 46, p. 101-110, 2020.OH, K. Y.; LEE, M. J.; JEON, S. W. Development of the Korean Climate Change Vulnerability Assessment Tool (VESTAP)—Centered on Health Vulnerability to Heat Waves. **Sustainability**, 2017. Available at: http://www.mdpi.com/journal/sustainability. Accessed on: 6 dez 2023.

MILLS, J. N.; GOYAL, M.; HARLOW, J. K.; GERBER, S. I.; BROWN, M. J.; JENNINGS, W. G. Changes in environmental conditions and their impact on leptospirosis outbreaks in the tropics. **International Journal of Environmental Research and Public Health**, v. 7, n. 2, p. 666-677, 2010.

NORRIS, F. H. The epidemiology of trauma: Frequency and impact of different potentially traumatic events on different demographic groups. **Journal of Consulting and Clinical Psychology**, v. 71, n. 2, p. 231-240, 2002.

NORRIS, F. H.; FRIEDMAN, M. J.; WATSON, P. J.; BYRNE, C. M.; DIAZ, E.; KANIASTY, K. Resilience and vulnerability: Adaptation in the context of childhood adversities. **Journal of Traumatic Stress**, v. 15, n. 2, p. 113-120, 2002.

NORRIS, F. H.; WEISS, D. S.; FOA, E. B. Methods for Disaster Mental Health Research. New York: **Guilford Press**, 2016.

NOY, I.; BIRK, D. The macroeconomic consequences of disasters. **Journal of Development Economics**, v. 88, n. 2, p. 221-231, 2009.

PANAPHUT, T.; DOMRONGKITCHAIPORN, S.; THINKAMROP, B. Prognostic factors of death in leptospirosis: A prospective cohort study in Khon Kaen, Thailand. **International Journal of Infectious Diseases**, v. 6, n. 1, p. 52-59, 2002.

PERROTTA, G.; HALL, M.; BECKER, A. The impact of climate change on landslide occurrence. **Landslides**, v. 15, n. 4, p. 631-648, 2018.

PRUSS, A.; KAY, D.; FEWTRELL, L.; BARTRAM, J. Estimating the burden of disease from water, sanitation, and hygiene at a global level. **Environmental Health Perspectives**, v. 110, n. 5, p. 537-542, 2019.

PRÜSS-USTÜN, A.; WOLF, J.; CORVALAN, C.; BOS, R.; NEIRA, M. Preventing disease through healthy environments: A global assessment of the burden of disease from environmental risks. **Environmental Health Perspectives**, v. 122, n. 8, p. 787-794, 2014.

ROLNIK, R. Tenure security and the new urban agenda. **International Journal of Urban and Regional Research**, v. 37, n. 3, p. 616-627, 2013.

SANTOS, M. R. da S.; VITORINO, M. I.; PEREIRA, L. C. C.; PIMENTEL, M. A. da S.; QUINTÃO, A. F. Vulnerabilidade Socioambiental às Mudanças Climáticas: Condições dos Municípios Costeiros no Estado do Pará. **Revista Ambiente e Sociedade**, São Paulo, v. 24, 2021. DOI: http://dx.doi.org/10.1590/1809-4422asoc20200167r1vu2021L3AO. 22 páginas. Accessed on: 10 dez. 2023.

SEFTIANI, S.; ASTUTI, Y. The vulnerability of urban area on climate change and dengue haemorrhagic fever (DHF): Case study in Semarang City. **IOP Conf. Series: Earth and Environmental Science**, 2021. Available at: https://doi.org/10.1088/1755-1315/739/1/012046. Accessed on: 22 dez. 2023.

SEMENZA, J. C.; MENNE, B. Climate change and infectious diseases in Europe. **The Lancet Infectious Diseases**, v. 9, n. 6, p. 365-375, 2009.

SIMMONS, A.; WEISS, B.; FOA, E. B. Cognitive behavioral therapy for PTSD: A case formulation approach. **Journal of Anxiety Disorders**, v. 27, n. 6, p. 635-641, 2013.

ISSN 2318-8472, v. 12, n. 86, 2024

SHAFFER, R. M.; SELLERS, S. P.; BAKER, M. G.; KALMAN, R. de B.; FROSTAD, J.; SUTER, M. K.; ANENBERG, S. C.; BALBUS, J.; BASU, N.; BELLINGER, D. C.; BIRNBAUM, L.; BRAUER, M.; COHEN, A.; EBI, K. L.; FULLER, R.; GRANDJEAN, P.; HESS, J. J.; KOGEVINAS, M.; KUMAR, P.; LANDRIGAN, P. J.; LANPHEAR, B.; LONDON, S. J.; ROONEY, A. A.; STANAWAY, J. D.; TRASANDE, L.; WALKER, K.; HU, H. Improving and Expanding Estimates of the Global Burden of Disease Due to Environmental Health Risk Factors. **Environmental Health Perspectives**, 2019. Available at: https://doi.org/10.1289/EHP5496. Accessed on: 13 dez. 2023.

SHEFFIELD, P. E.; LANDRIGAN, P. J. Global Climate Change and Children's Health: Threats and Strategies for Prevention. **Environmental Health Perspectives**, v. 119, n. 3, p. 291-298, 2011. Available at: https://doi.org/10.1289/ehp.1002233. Accessed on: 13 dez. 2023.

SCHLOSBERG, D.; COLLINS, L. From environmental to climate justice: Climate change and the discourse of environmental justice. **Wiley Interdisciplinary Reviews: Climate Change**, v. 5, n. 3, p. 359-374, 2014.

SMIT, B.; WANDEL, J. Adaptation, adaptive capacity and vulnerability. **Global Environmental Chan**ge, v. 16, n. 3, p. 282-292, 2006.

STEFFEN, W.; RICHARDSON, K.; ROCKSTRÖM, J.; SCHELLNHUBER, H. J.; CORNELL, S. E.; FETZER, I.; BENNETT, E. M.; BIGGS, R.; CARPENTER, S. R.; DE VRIES, W.; DE WIT, C. A.; FOLKE, C.; GERTEN, D.; HEINKE, J.; MACE, G. M.; PERSSON, L. M.; RAMANATHAN, V.; REYERS, B.; SÖRLIN, S. Planetary boundaries: Guiding human development on a changing planet. **Science**, v. 347, n. 6223, p. 736, 2018.

TIBÚRCIO, L. H.; CORRÊA, M. de P. Análise da vulnerabilidade da microrregião de Itajubá por meio do IVG com vistas à mitigação dos impactos causados pelas mudanças climáticas. **Ambiente & Sociedade**, São Paulo, v. XV, n. 3, p. 123-139, set.-dez. 2012. Accessed on: 10 dez. 2023.

TOAN, D. T. T.; KIEN, V. D.; GIANG, K. B.; MINH, H. V.; WRIGHT, P. CLIMATE CHANGE AND HEALTH IN VIETNAM Perceptions of climate change and its impact on human health: an integrated quantitative and qualitative approach. **Glob Health Action**, 2014. Available at: http://dx.doi.org/10.3402/gha.v7.23025. Accessed on: 6 dez 2023.

TURNER, B. L. Vulnerability and resilience: Coalescing or paralleling approaches for sustainability science? **Global Environmental Change**, v. 22, n. 3, p. 610-617, 2022.

TURNER, M. S. Climate Change Hazards + Social Vulnerability = A Recipe for Disaster. **Generations**, 2022. Available at: www.generations.asaging.org. Accessed on: 4 jun. 2024.

USHANKOV, A. I.; AKATOV, A. K. Hypothermia and cold injuries in natural disasters. **Critical Care**, v. 18, n. 4, p. 454-456, 2014.

WILLIAMS, A. A.; ALLEN, J. G.; CATALANO, P. J.; BUONOCORE, J. J.; SPENGLER, J. D. The Influence of Heat on Daily Police, Medical, and Fire Dispatches in Boston, Massachusetts: Relative Risk and Time-Series Analyses. **American Journal of Public Health (AJPH)**, 2020. Available at: https://doi.org/10.2105/AJPH.2020.110.05. Accessed on: 13 dez. 2023.

WILLIAMS, A. A.; ALLEN, J. G.; CATALANO, P. J.; SPENGLER, J. D. The Role of Individual and Small-Area Social and Environmental Factors on Heat Vulnerability to Mortality Within and Outside of the Home in Boston, MA. **Climate**, 2020. Available at: https://doi.org/10.3390/cli8020029. Accessed on: 6 dez 2023.

WILLIAMS, S.; KOVATS, S.; HOPKINSON, N. Building resilience to extreme weather events: A policy perspective. **Environmental Science & Policy**, v. 98, p. 202-210, 2019.

ZHANG, R. et al. From concept to action: a united, holistic and One Health approach to respond to the climate change crisis. **Infectious Diseases of Poverty**, 2022. Available at: https://doi.org/10.1186/s40249-022-00941-9. Accessed on: 10 dez. 2023.

6.4 Newspaper article

G1. (2024). Tragédia no RS: inundações atingiram mais de 35 mil refugiados. Recuperado de https://g1.globo.com

G1. (2024). A cronologia da tragédia no Rio Grande do Sul. Recuperado de https://g1.globo.com

G1. (2024). Chuvas no RS: entenda as causas de uma das maiores tragédias. Recuperado de https://g1.globo.com

G1. (2024). Especialistas dizem o que pode ser feito para evitar desastres como o que assola o Rio Grande do Sul. Recuperado de https://g1.globo.com

ISSN 2318-8472, v. 12, n. 86, 2024

Portal G1. Temporal devastador no Litoral Norte de SP completa uma semana:veja resumo da tragédia. 2023. Recuperado em: https://g1.globo.com/sp/vale-do-paraiba-regiao/noticia/2023/02/26/temporal-devastador-no-litoral-norte-de-sp-completa-uma-semana-veja-resumo-da-tragedia.ghtml

Portal G1. Chuva causa alagamentos, falta de energia e afeta trens no RJ; vídeo mostra barraca virando sobre funcionários de barraca de pastel. 2024. https://g1.globo.com/rj/rio-de-janeiro/noticia/2024/01/11/chuva-forte-causa-transtornos-no-rio-de-janeiro.ghtml

Portal G1. Chuva provoca estragos em estradas no sul da Bahia. 2022. Recuperado em: https://g1.globo.com/jornal-nacional/noticia/2022/12/23/chuva-provoca-estragos- em-estradas-no-sul-da-bahia.ghtml

Portal G1. Cidade de SP tem queda de árvores, falta de luz e pontos de alagamento; Rua 25 de Março 'vira rio'. 2024 https://g1.globo.com/sp/sao-paulo/noticia/2024/01/08/cidade-de-sp-registra-pancadas-de-chuva-e-rajadas-de-vento-nesta-segunda.ghtml

Portal G1. Estiagem: sobe para 21 número de municípios do RS em situação de emergência. 2022. Recuperado em https://g1.globo.com/rs/rio-grande-do-sul/noticia/2022/12/28/estiagem-sobe-para-21-numero-de-municipios-do-rs-em-situacao-de-emergencia.ghtml

Portal G1. Ocupação irregular de áreas em Petrópolis mais do que dobrou entre 1985 e 2020. 2022. https://g1.globo.com/rj/regiao-serrana/noticia/2022/02/23/ocupacao-irregular-de-areas-em-petropolis-mais-do-que-dobrou-entre-1985-e-2020.ghtml

Portal G1. Sobe para 141 número de botos mortos durante a seca no Amazonas. 2023. Recuperado em https://g1.globo.com/am/amazonas/natureza/amazonia/noticia/2023/10/10/seca-historica-ja-matou-141-botos-no-lago-de-tefe-no-amazonas.ghtml

Portal G1. Temporal com deslizamentos deixa mortos em Petrópolis. 2022. Recuperado em: https://g1.globo.com/rj/rio-de-janeiro/noticia/2022/02/15/chuva-em-petropolis-causa-alagamentos-e-arrasta-carros-fotos.ghtml

6.5 Television program

FANTÁSTICO. Rio de Janeiro: TV Globo, 2 jun. 2024. Programa de televisão.