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Artigo

# Brazil's vulnerability to climate change: an analysis based on the University of Notre Dame's Global Adaptation Initiative (ND-GAIN)

*A vulnerabilidade do Brasil às mudanças climáticas: uma análise baseada na Iniciativa de Adaptação Global da Universidade de Notre Dame (ND-GAIN)*

*La vulnerabilidad de Brasil al cambio climático: un análisis basado en la Iniciativa de Adaptación Global (ND-GAIN) de la Universidad de Notre Dame*

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**Abstract:** *This article aims to analyze Brazil's vulnerability to climate change based on the Notre Dame Global Adaptation Initiative (ND-GAIN), from 1995 to 2021. The methodology applied was a bibliographical review on the concept of vulnerability and a case study of Brazil based on the ND-GAIN. As a result, it was observed that Brazil's vulnerability has worsened or decreased in different moments. More recently, Brazil has relatively low vulnerability, but also low response capacity to face the challenges of climate change.*
**Keywords***: Climate Change. Vulnerability. Brazil. ND-GAIN.*
**Resumo:** *Este artigo tem como objetivo analisar a vulnerabilidade do Brasil à mudança do clima com base no Índice de Adaptação Global da Universidade de Notre Dame (ND-GAIN), de 1995 a 2021. A metodologia aplicada foi uma revisão bibliográfica sobre o conceito de vulnerabilidade e um estudo de caso do Brasil com base no ND-GAIN. Como resultado, observou-se que a vulnerabilidade do Brasil aumentou ou diminuiu em diferentes momentos. Mais recentemente, o Brasil apresenta vulnerabilidade relativamente baixa, mas também baixa capacidade de resposta para enfrentar os desafios da mudança do clima.*
**Palavras-chave:** *Mudança do clima. Vulnerabilidade. Brasil. ND-GAIN.*
**Resumen:** *Este artículo tiene como objetivo analizar la vulnerabilidad de Brasil al cambio climático a partir de la Iniciativa de Adaptación Global de Notre Dame (ND-GAIN), de 1995 a 2021. La metodología aplicada fue una revisión bibliográfica sobre el concepto de vulnerabilidad y un estudio de caso de Brasil basado en el ND-GAIN. Como resultado, se observó que la vulnerabilidad de Brasil aumentó o disminuyó en diferentes momentos. Más recientemente, Brasil tiene una vulnerabilidad relativamente baja, pero también una baja capacidad de respuesta para enfrentar los desafíos del cambio climático.*
**Palabras clave:** *Cambio climático. Vulnerabilidad. Brasil. ND-GAIN.*

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## Introduction

Recent extreme weather events around the world draw attention to how quickly the impacts of climate change are worsening. In 2023, Brazil faced several extreme events that harmed the health and well-being of the population, housing infrastructure, food production, water availability and the economy. In September 2023, cities in Vale do Taquari, in Rio Grande do Sul, were hit by the passage of an extratropical cyclone that caused strong storms. With the intensity of the rains, the Taquari River overflowed, flooding several cities and forcing thousands of people to leave their homes. The cyclone left 8 people missing and 50 dead (G1, 2023a).

Brazil also faced severe heat waves in September 2023, when the heat was a record for the year in the cities of Rio de Janeiro (39.9ºC), Belo Horizonte (37.1ºC), São Paulo (36.5ºC) and Curitiba (33.1ºC) (O Globo, 2023). Another climate event experienced by Brazil in 2023 was the extreme drought in the Amazon region, which has affected over 557 thousand people across the state (G1, 2023b).

As climate change worsens, food production systems and water availability are affected, as well as infrastructure and housing, ecosystem services and biodiversity (IPCC, 2022). Aware of the growing threat that climate change poses to people's lives and the health of the planet, this article's goal is to analyze Brazil's vulnerability to climate change. To do so, a bibliographical review is made to discuss the concept of vulnerability and its focus on climate change. Then, the ND-GAIN is introduced. Finally, a case study is developed mobilizing this index, to understand Brazil's vulnerability from 1995 to 2021, first and last years of which ND-GAIN makes the data available.

## Vulnerability to climate change

Vulnerability is a multidisciplinary concept. In common sense, it means "the quality or state of being vulnerable" (Oxford…, n/p, n/da). To be vulnerable means that something or someone may be wounded or is susceptible to receiving physical injury (Oxford…, n/db). It was from the 1980s onwards that this term began to be used more frequently, especially in research on risks and dangers related to environmental and climate issues (Iwama *et. al.*, 2016).

To understand this concept applied to climate change, first it is important to clarify that climate change is a "change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods" (United Nations, 1992, p.3). Its adverse effects are the changes in the physical environment that affect the resilience and productivity of ecosystems, the well functioning of the socio-economic systems and human health and welfare (United Nations, 1992).

Vulnerability to climate change refers to the susceptibility of an individual or social group to suffer damage resulting from a certain amount of exposure to a climate risk (Turner, 2016). Wisner (2003) discusses that it is the combination of different factors that determines the degree of vulnerability of a person, which in turn is directly related to the socio economic condition of individuals, influencing their ability to respond, face, resist and recover from an event. That said, usually the poorest populations are those most exposed to different risks, and, therefore, are the most vulnerable.

Even though all countries are vulnerable to climate change, the intensity of this vulnera-

bility is uneven. This point will be discussed in the following section. For now, it is worth making it clear that people or countries with the fewest resources have the greatest difficulties in facing and adapting to climate change.

To think about vulnerability involves considering the various dimensions in which an individual or group is inserted such as social, economic and political. Regarding a country's vulnerability, it is necessary to understand these aspects, alongside its resources, especially economical and political, to face, adapt and mitigate the effects of climate change. Finally, as is not the purpose of this article to carry out an in-depth bibliographical review on the concept of climate vulnerability, it is believed that this brief mobilization of the concept is enough to achieve this article's main objective.

## The Notre Dame Global Adaptation Initiative

The ND-GAIN goal is to summarize a country's vulnerability to climate change associated with its readiness to improve its resilience in the face of climate change. Currently, ND-GAIN measures the vulnerability of 185 countries considering two dimensions: (1) vulnerability; and (2) readiness. Both dimensions have their own index, but the ND-GAIN climate vulnerability index is calculated from the combination of these two.

First dimension concerns vulnerability, meaning the "propensity or predisposition of human societies to be negatively impacted by climate hazards" (Chen *et. al.*, 2023, p. 5). The IPCC (2022, p. 2911) understand hazards as "the potential occurrence of a natural or human-induced physical event or trend that may cause loss of life, injury or other health impacts, as as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources". This dimension is measured based on six sectors: food; water; health; ecosystem services; human habitat; infrastructure. Each has six indicators, totalizing 36 indicators of vulnerability. From these, the ND-GAIN vulnerability index is calculated varying between the scores of 0 and 1. Scores closer to 0 express less vulnerability, while scores closer to 1 express greater vulnerability. To illustrate, in 2021, the country with the lowest vulnerability was Switzerland (0.244) and the country with the highest vulnerability was Somalia (0.678) (University…, 2023).

Second dimension concerns readiness, meaning a country's capacity "to make effective use of investments for adaptation actions thanks to a safe and efficient business environment" (Chen *et. al.*, 2023, p. 6). This dimension is measured based on three components: economic; governance; social. Each has its indicators, totalizing 9 indicators of readiness. From these, the ND-GAIN readiness index is calculated also varying between the scores of 0 and 1, but here the logic is reversed in relation to the previous index. Here, scores closer to 1 express greater readiness and scores closer to 0 express less readiness. To exemplify, in 2021, the country with the highest readiness was Singapore (0.805) and the country with the lowest readiness was Central African Republic (0.138) (University…, 2023).

Once the two indexes were shown, as well as the 2021 data for each, the results of the ND-GAIN final climate vulnerability index will be presented. Here, the index varies from 0 to 100. The higher the score, the better (less vulnerability and more readiness). On

the other hand, the lower the score, the worse (higher vulnerability and less readiness). In 2021, the least vulnerable country was Norway (75.0), while the most vulnerable country was Chad (27.0) (University…, 2023).

Considering the performances of the top and last countries in the three indexes, something important can be observed. The top performers (Switzerland, Singapore and Norway) are highly developed countries, while the worst performers (Somalia, Central African Republic, Chad) are amongst the 46 countries on the group of the Least Developed Countries in the World (UNCTAD, 2021). This draws attention to a particular aspect, the importance of the resources held by countries, whether financial, political, diplomatic, or others. This importance becomes quite clear when we observe the case of Norway and Chad, countries that have a huge discrepancy between their performances in economic, social and political terms.

On the economic dimension, in 2021, Norway's Gross Domestic Product was 490.29 billion dollars, while Chad's was 11.78 billion (World Bank Data, 2024). On the social dimension, in 2021, both countries had very different performances on the Human Development Index. While Norway had the second best performance with the score of 0.961, Chad had one of the worst performances with the score of 0.394 (United Nations Development Programme, 2024). On the political dimension, both countries had a very different performance on the Corruption Perceptions Index in 2021. While Norway was the 4th country with the least corruption index, with a score of 85 out of 100, Chad was the 20th country with the biggest corruption index, with a score of 20 out of 100 (Transparency International, 2024).

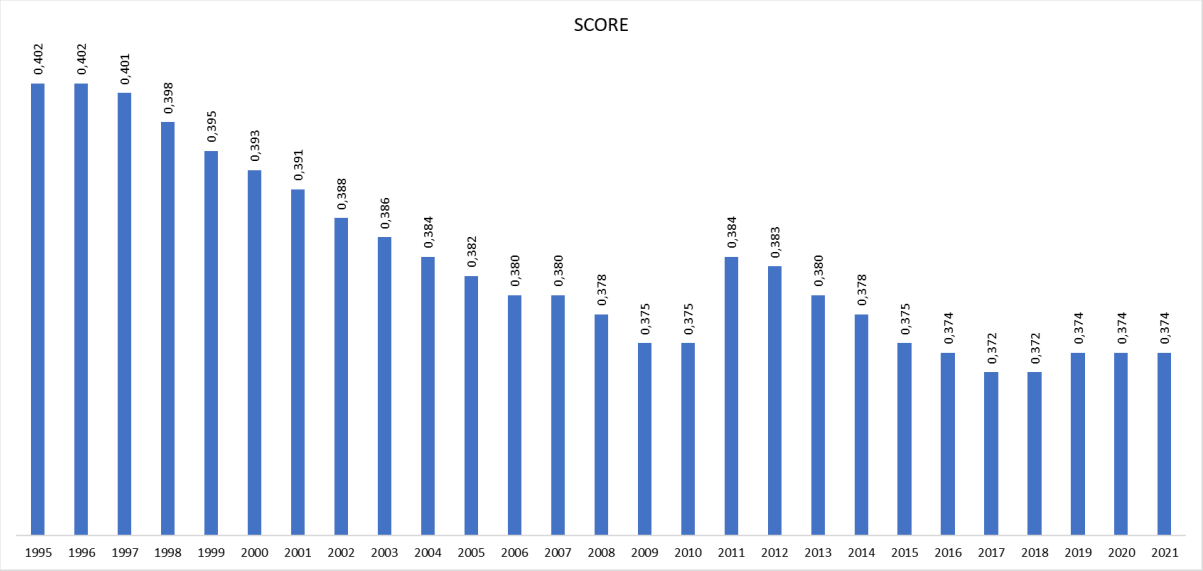
Even though developed countries are the major responsible for climate change, they are the ones with a lower level of vulnerability, because they have better conditions to respond to its threats. That is the case of Norway, who has extensive financial resources and strong institutional capabilities. On the other hand, developing countries are amongst the least responsible for climate change, and yet they are the ones with the highest levels of vulnerability, because they don't have the same conditions to respond to its effects, considering their economical, political and social dynamics are very different from developed countries. That is the case of Chad, one of the poorest countries in the world who does not have the necessary resources to promptly face climate change.

## Brazil's vulnerability to climate change (1995-2021)

In order to achieve the objective of this article, this section is dedicated to analyze Brazil's vulnerability. First the country's performance in the vulnerability index considering the six sectors will be explored. Second, Brazil's performance in the readiness index considering the three components will be explored. Finally, its performance in the final climate vulnerability index will be explored.

Figure 1 shows Brazil's performance in the vulnerability index.

Figure 1 - Brazil's performance in the ND-GAIN vulnerability index (1995-2021)




Source: elaborated by the author from University of Notre Dame Global Adaptation Initiative (2023).

Figure 1 shows Brazil's performance in this index improved and worsened in the period analyzed. In 1995, its vulnerability was relatively high, but it decreased steadily year by year until 2010. The country's vulnerability increased again in 2011, falling slightly again in 2012. This decrease continued until 2018. In 2019, Brazil's vulnerability increased again and has remained stable ever since. The years in which Brazil had its best performance were 2017 and 2018 (0.372) and it had its worst performance in 1995 and 1996 (0.402). From 1995 to 2021, Brazil suffered a negative variation of 0.028 in this dimension, which means that it became less vulnerable.

When analyzing Brazil's performance in the six vulnerability sectors, it was identified an increase in vulnerability in two and a drop in the other four. Table 1 shows these results.

Table 1 - Brazil's performance in the six vulnerability sectors (1995-2021)

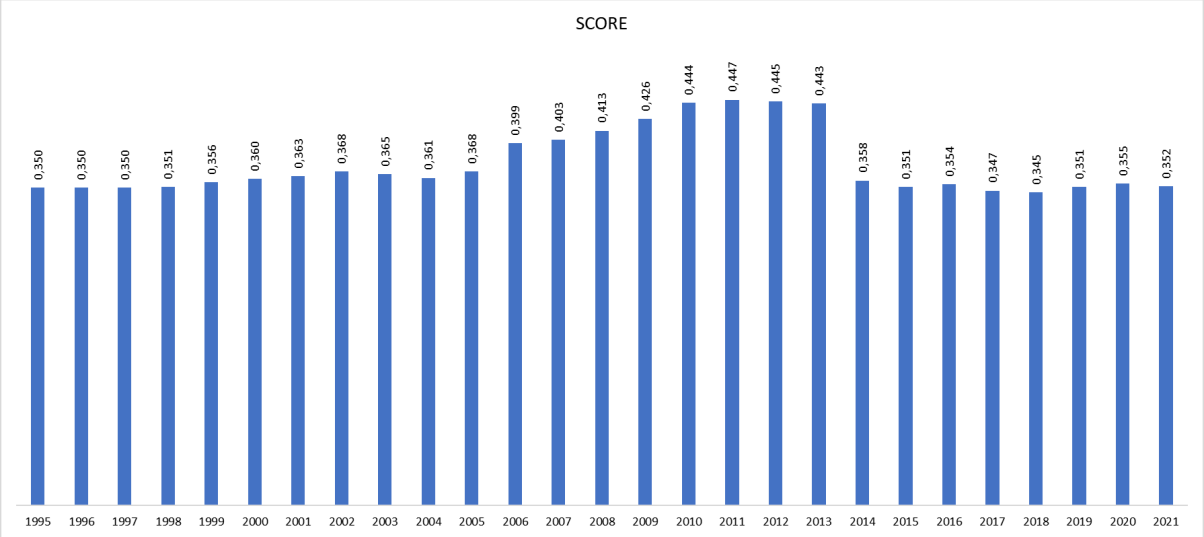
| Sector | 1995 | 2021 | Variation |
|---|---|---|---|
| Food | 0.424 | 0.381 | -0.043 |
| Water | 0.272 | 0.273 | +0.001 |
| Health | 0.479 | 0.381 | -0.098 |
| Ecosystem services | 0.433 | 0.437 | +0.004 |
| Human habitat | 0.637 | 0.607 | -0.03 |
| Infrastructure | 0.167 | 0.163 | -0.004 |

Source: elaborated by the author from University of Notre Dame Global Adaptation Initiative (2023).

Even if the variation was very small, Table 1 shows that the sectors in which Brazil became less vulnerable between 1995 and 2021 were food, health, human habitat and infrastructure. Otherwise, Brazil became more vulnerable in water and ecosystem services sectors.

Figure 2 shows Brazil's performance on the readiness index.

Figure 2 - Brazil's performance in the ND-GAIN readiness index (1995-2021)




Source: elaborated by the author from University of Notre Dame Global Adaptation Initiative (2023).

As it can be seen in Figure 2, Brazil's performance in this index was more constant than in the previous dimension. It is shown the country's readiness increased from 1995 to 2002, having a little step down in 2003 and 2004, increasing back again from 2005 to 2012. The biggest drop in Brazil's readiness was observed in 2014 (0.358), which continued to decrease in the following years until 2021 (0.352). From 1995 to 2021, Brazil suffered a very small positive variation of 0.002. In general terms, it cannot be said whether the country was less or more ready, given the close score between 1995 (0.350) and 2021 (0.352). Finally, Figure 2 shows that the years in which Brazil had its best performance were 2011 (0.447), while the year it had its worst performance were 2018 (0.345).

During the analysis of Brazil's performance in the three readiness components, it was identified that there was an increase in one of them and a drop in the other two. Table 2 shows these results.

Table 2 - Brazil's performance in the three readiness components (1995-2021)

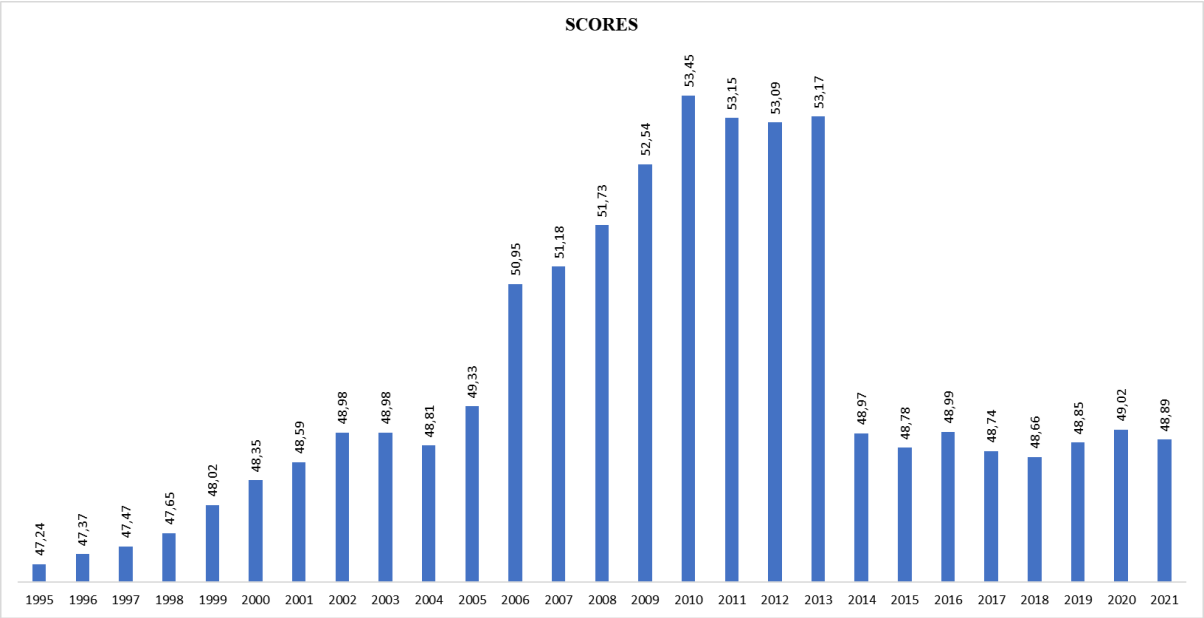
| Component | 1995 | 2021 | Variation |
|---|---|---|---|
| Economic | 0.417 | 0.300 | -0.117 |
| Governance | 0.495 | 0.434 | -0.061 |
| Social | 0.140 | 0.321 | +0.181 |

Source: elaborated by the author from University of Notre Dame Global Adaptation Initiative (2023).

Here, the variation was a bit bigger than in the previous dimension. Table 2 shows that the component in which Brazil became more ready between 1995 and 2021 was the social one. On the other hand, Brazil became less ready in the economic and governance components, with the greatest negative variation being observed for the economic.

Having discussed Brazil's vulnerability and readiness according to the ND-GAIN, now the country's performance in the final climate vulnerability index will now be analyzed. Figure 3 shows Brazil's performance in this index.

Figure 3 - Brazil's performance in the ND-GAIN climate vulnerability index




Source: elaborated by the author from University of Notre Dame Global Adaptation Initiative (2023).

As Figure 3 shows, Brazil's vulnerability to climate change also increased and decreased during the period analyzed. In 1995, the country was significantly vulnerable. This vulnerability began to decrease in the following years with the country's scores becoming higher until 2003. However, in the year of 2004, its score decreased again. In 2005 Brazil's score increased again, which led the country to its period of best improvement performances, which means the country was less vulnerable during the years of 2006-2010. From then until 2013, its score decreased again, but not as significantly as the decrease of the following years.

The most significant drop in Brazil's score, which demonstrates a relevant increase in the country's vulnerability, occurred between 2013 and 2014, when the country went from a score of 53.17 to a score of 48.97. The country's best performance, that is, its lowest vulnerability, was in 2010 (53.45), and its worst performance, meaning its highest vulnerability was in 1995 (47.24). Finally, it is possible to observe a worsening of Brazil's vulnerability in recent years, with its score being less than 50.

Considering the data shown before, one can wonder: if Brazil's vulnerability decreased (Figure 1 and Table 1), why is the country still

vulnerable? That would be because there was also a worsening of the country's readiness, especially in the economic and governance components (Table 2). Therefore, even if Brazil reduces its vulnerability in the six sectors, if its readiness does not improve, the country will remain vulnerable and incapable of facing and responding to the challenges imposed by climate change.

After analyzing Brazil's vulnerability according to the ND-GAIN, it is important to mention that the country's domestic policy conditions to deal with climate issues probably impacts on the positive or negative result as seen in the analysis. Internationally, Brazil is known for participating in institutional structures of climate governance. Since the 1970s, when the environmental and climate agenda was strengthened, Brazil has signed and ratified documents such as the Montreal Protocol (1987), the Kyoto Protocol (1997) and the Paris Agreement (2015). Brazil is also a Party to the UNFCCC, established in 1992, and, historically, participates in the Conferences of the Parties (COP) and other major conferences held within the scope of the United Nations.

Although Brazil has an active history with regard to the environmental and climate agendas, it is worth mentioning that there were times when, domestically, Brazil adopted a more serious stance regarding climate issues, adopting measures and creating policies for mitigation or adaptation, just as there were moments in which the country adopted a less serious approach. The two most evident examples of these moments are the Lula da Silva governments (2003-2010), where some considerable efforts were made, and the Jair Bolsonaro government (2019-2022), where many actions were undone, with the purpose of leveraging other areas, such as the national economy or security.

It is not the purpose of this article to discuss the domestic policies created or undone throughout Brazil's governments between 1995 and 2021 regarding climate issues. For now, it is enough to mention that the way in which governments conducted their actions both domestically and internationally may exercise a direct influence on Brazil's vulnerability to climate change.

## Conclusion

Between 1995 and 2021, Brazil became less vulnerable. The country managed to reduce its score from 0.402, in 1995, to 0.374, in 2021, which means it reduced its vulnerability. Regarding the country's readiness, it is hard to say if Brazil indeed improved or not, considering the very small variation of +0.002. Either way, the country had a score of 0.350, in 1995, which is considerably low, and a score of 0.352, in 2021, which is also a low score. That said, Brazil's readiness remained almost the same. Regarding the final index that summarizes a country's vulnerability to climate change, Brazil's performance had an improvement. If the country's score in 1995 was 47.24, in 2021 it was 48.89, which means its vulnerability decreased.

During the analysis conducted, it was evident that the readiness dimension of the ND-GAIN has a very important role in a country's vulnerability, having a great impact on the final result of Brazil's vulnerability to climate change. When analyzing the country's performance in the three components of readiness, individually, it was observed that there is a major deficiency, especially in the economic and governance components. In practice, this means that Brazil does not have sufficient resources to face the impacts of climate change effectively, neither in the economic nor in the governance dimension.

The combination of these factors culminates in the country's reality. Even if Brazil's vulnerability has decreased, the country is still considerably vulnerable. That said, as Brazil has a considerable level of vulnerability and a low level of readiness, the country faces many challenges regarding the adaptation and mitigation of climate change. In some way, the country's vulnerabilities could be managed, but there is an urgent need for improvements, especially in the economic readiness dimension, which may help Brazil to better adapt for the many future challenges to come.

Since this article set out to analyze Brazil's climate vulnerability between 1995 and 2021, it is believed that the objective was achieved. A possible path for new research based on the contribution made here would be to understand the role of different Brazilian governments in this period regarding the climate issue, in order to understand whether the way in which governments conduct domestic and external policy to the climate agenda influences the different levels of vulnerability.

Finally, it is worth highlighting that this study could contribute greatly to the epistemic study of environment and vulnerability in the field of International Relations, especially regarding the elaboration of public policies, including foreign policy, to deal with the effects of climate change in Brazil and in the world. In this sense, the methodology presented by ND-GAIN makes a very important contribution by allowing the assessment of a country's vulnerability to climate change and other global challenges, taking into account its resilience capacity.

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