Climate changes and tourism: an estimate of the impact on the economy of Salvador, a Brazilian municipality

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Abstract : The present study aimed to project the economic impacts of climate change on tourist activity in Salvador, a municipality in the state of Bahia in Brazil. To this end, an inter-regional Computable General Equilibrium (CGE) model with recursive dynamics was used, the model developed for the analysis of the Brazilian economy and regionalized exclusively for the purposes of this research, whose theoretical structure follows the TERM model developed by the Center of Policy Studies in Australia, which was called TERM - Salvador. The simulations were translated as a decrease in demand for tourist services (tourist flow x tourist spending), through climate impact chains built based on the theoretical framework contained in the 5th Assessment Report (AR5) of the IPCC and the Risk Supplement to Vulnerability Sourcebook from the German International Cooperation Agency for Sustainable Development (GIZ). Two scenarios were simulated regarding the existence or not of adaptive capabilities at the destination, for the time horizons of 2030, 2050 and 2100. In both cases and in all projected years, the losses verified are significant, reaching R$3 billion in the year 2030, R$11 billion in 2050 and R$40 billion in 2100, totaling R$1.4 trillion if the accumulated result for the entire period is considered.

Key words : Tourism economy, economic and environmental impact, risks of climate change, Computable General Equilibrium.

1. INTRODUCTION

Tourism is an important economic activity in many Brazilian regions, especially on the Northeast coast. According to the Monthly Services Survey from Brazilian Institute of Geography and Statistics (IBGE), until August 2022 the special aggregate of tourist activities showed an expansion of 39.1% compared to the same period last year. States such as Bahia and Ceará managed to expand the Tourist Activities Volume Indicator by 40.8% and 44.2% in the last twelve months, respectively. This means that the tourism sector is recovering from the effects of the COVID-19 pandemic (IBGE, 2022). However, from a long-term perspective, this activity may be compromised by another type of threat, this time related to the risks of climate change to the attractiveness of destinations in the region.

Salvador, capital of the state of Bahia, is one of the main tourist destinations in northeastern Brazil. Its privileged position at the mouth of the largest bay in Brazil, as well as its rich historical and cultural heritage, offer a diverse range of attractions for national and foreign tourists. In fact, aspects that make Salvador a much sought

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after destination by tourists today, such as the proximity to the coast and the eternal summer temperature, could compromise this same tourism sector in the future, due to effects such as the rise in the level of the sea or the increase in atmospheric temperature, which is predicted to severely affect the intertropical belts of the planet (IPCC, 2007; 2014).

Climate change is a phenomenon "attributed directly or indirectly to human activity, which alters the composition of the atmosphere and adds to the natural climate variability observed over comparable periods of time" (UN , 1992, p.4). According to the 6th Assessment Report (AR6) of the Intergovernmental Panel on Climate Change (IPCC), the period between 1850 and 2020 was the hottest in the last 2000 years, with anthropogenic influence having been responsible for an increase of 1, 07ºC in the planet's global average temperature. The report points out that, between 1901 and 2018, there was a 20 cm rise in sea level resulting, in part, from the combination of warming of the ocean surface and the increase in the melting of polar ice caps (IPCC, 2021).

In view of this new reality, it is considered essential to understand the possible impacts that tourist activity may suffer as a result of this phenomenon. In this sense, this article aimed to project the economic impacts arising from climate change on tourist activity in the municipality of Salvador resulting from changes in climate, outlining scenarios, with and without the development of adaptive capabilities by the municipal administration, for the years 2030, 2050 and 2100.

The simulations were carried out based on an inter-regional Computable General Equilibrium (CGE) model with recursive dynamics, developed for the analysis of the Brazilian economy and regionalized exclusively for the purposes of this research, called TERM - Salvador. This work is divided into three sections, in addition to this Introduction and Final Considerations. The first presents a brief review of the literature on climate change, as well as contextualizing tourist activity in Salvador. The second section exposes the methodology developed, based on the Computable General Equilibrium model, and, finally, the last section presents the simulations and discusses the results.

2. CLIMATE CHANGE AND ITS IMPACTS ON TOURISM IN SALVADOR

Tourism was the service sector activity most affected by the pandemic caused by Sars-Cov2 (COVID-19) with the number of international arrivals recording a drop of 73% in 2020, compared to the previous year, reaching 90% in some developing countries. Considering the impact of this decrease in the flow of visitors in all sectors directly related to tourism, it is estimated that the pandemic was responsible for losses of US$2.4 trillion and US$1.8 trillion in global GDP in the years 2020 and 2021, respectively (UNCTAD, 2022).

In the case of Brazil, according to estimates by Fundação Getúlio Vargas (FGV), the production volume of the sector's activities was, in 2021, around 4.2% lower than that observed in 2019. They estimate a total loss of the Brazilian tourism sector of R$116.7 billion in the 2020-2021 biennium (FGV, 2020). Despite the crisis faced by tourism in the pandemic years, the effects of which will still be felt for some time, it is considered a temporary and temporary crisis. In the long term, however, it is projected that climate change could cause deeper and more lasting changes, capable of causing structural transformation in this sector. (SCOTT, GOSSLING, HALL, 2012; DICKINSON, LUMSDON, ROBBINS, 2011)

This understanding is justified by understanding the complexity that involves the interactions between the components of tourism systems affected by climate change and the links that the activity maintains with other sectors of the economy and society (MORENO, BECKEN, 2009).

Thus, the occurrence of extreme climatic factors and their consequences should negatively influence the attraction of visitors to a given region, since tourists may rethink their decisions regarding the choice of destination, the time in which they will travel, the activities they will develop and the length of stay, all depending on the possible levels of discomfort and dissatisfaction that they expect to face. (ATZORI, 2018; BARRIOS, IBAÑEZ, 2015; BUJOSA, RIEIRA and TORRES, 2015; NICHOLS, 2015; KOBERL, PRETTENHALER, BIRD, 2016; LEMESIOS et al, 2016; DEL CHIAPPA et al, 2018; PHILIPS, JONES and THOMAS, 2018).

Other risks cited in the literature refer to damage to infrastructures and attractions important to the destination (YAN et al, 2015; HALL et al, 2016; STEWART, 2016; MEYNECKE, RICHARDS and SAHIN, 2017; GRIMM, ALCANTARA and SAMPAIO, 2018) and the resulting economic losses, mainly for communities that depend on the activity (NJOROGE, 2015; KOBERL, PRETTENHALER, BIRD, 2016; ROGERSON, 2016; MACKAY, 2017; PANDY, 2017; SIFOLO, HENAMA, 2017).

Such risks, if not considered by destinations, can compromise the competitiveness of the sector, and cause negative economic and social consequences. In Brazil, there is still little scientific production on the topic, with emphasis on the work of Grimm (2016 and 2019) and Grimm, Alcântara and Sampaio (2018) who address the implications of environmental and climate changes on tourism in the country, starting from analyzing global scenarios, and identifying opportunities and challenges for the sector.

With regard to Salvador, the locus of this study, represented on the map in Figure 1, sun and beach tourism is the most representative. Among visitors who seek out the City for leisure, 67.6% said they do so for its natural attractions, spread over more than 60 km of coastline, between beaches bathed by the Atlantic Ocean and Baía de Todos os Santos (SALVADOR, 2020a) . Cultural tourism appears in second place, motivated by the historical, ethnic, religious and gastronomic segments, which are also very susceptible to extreme weather conditions, notably with regard to walking *tours and* those aimed at an older public and less adapted to temperatures. elevated.

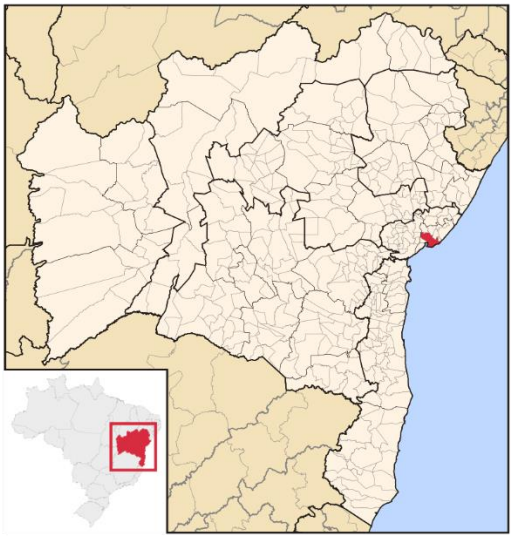

Figure 1: Map of the state of Bahia and its capital Salvador - Brazil.

Salvador's vulnerability to the occurrence of climate events is a reality felt by its residents over the last few decades, and recognized by recent technical studies (SOUSA et al, 2016; PBMC, 2016; SALVADOR, 2020b). Specifically with regard to tourism, such studies highlight the following potential impacts: a) landslides, landslides and floods in tourist areas, caused by intense rain and increased gusts of wind; b) formation of "heat islands" in the most urbanized areas and least equipped with green areas, with the expected increase in average temperatures; c) as a combination of the two previous factors, the proliferation of arboviruses and infectious diseases is expected and, d) reduction of sand strips on beaches and damage to historical monuments due to rising sea levels.

With regard to the tourism economy, methodological limitations make it difficult to accurately measure the economic importance of the activity for the City's economy. It is estimated that the participation of tourism in Salvador's GDP is between 4% and 6%, considering the formal sector, reaching 20% if businesses and informal occupations are included, data that is widely shared by the trade and corroborated by publications City Hall officials such as the recent Salvador Strategic Tourism Marketing Plan (PEMTS) (SALVADOR, 2020a). Study carried out by Tridello , Spinola and Cisalpino (2021), who consulted the main *stakeholders* involved with the sector in the City, concluded that the mentioned climate risks could represent considerable economic losses if adaptation or mitigation measures are not adopted.

The next section details the methodology adopted in the Study and will present the strategies used to simulate the City's possible economic losses in the various proposed scenarios.

3. METHODOLOGICAL ASPECTS

This work is a descriptive research of a quantitative nature, focused on the analysis of scenarios through an inter-regional Computable General Equilibrium (CGE) model with recursive dynamics, developed for the analysis of the Brazilian economy and regionalized exclusively for the purposes of this research. The model developed was called "TERM - Salvador".

The use of this type of modeling is due to its ability to deal with external shocks applied regionally. In CGE models, sectors are interrelated and the productive structure of economies or regions are explicitly treated. The CGE model projects the impacts of changes in relative prices, in addition to being based on the Walrasian (neoclassical) paradigm of general equilibrium where the balance between demand and supply is achieved by flexible prices with internally specified elasticities of imperfect substitution. In this sense, the response of any resource reallocation movement can be examined based on exogenous shocks that are reflected in relative prices (DOMINGUES, 2002; ALMEIDA, 2003; HADDAD, 2004; PEROBELL I, 2004).

Therefore, this type of modeling is capable of answering complex questions that involve several agents, such as the impacts of climate change on the economy and tourism sectors. This type of environmental impact can be dealt with explicitly through reductions in the levels of sectoral activities.

3.1 Theoretical Structure

TERM - Salvador is of the Australian/Johansen tradition [6], with a theoretical structure similar to The Enourmous Regional Model (TERM) (HORRIDGE, MADDEN and WITTWER, 2005). The central structure of the model is composed of blocks of equations that determine supply and demand relationships, derived from optimization hypotheses, and market equilibrium conditions. Furthermore, several national aggregates are defined in this block, such as aggregate employment level, GDP, trade balance and price indices. Predominantly non-linear equations, organized into blocks, which, once described in linearized forms, give rise to solutions based on growth rates.

The productive sectors minimize production costs subject to a technology of constant returns to scale in which the combinations of intermediate inputs and primary factor (aggregate) are determined by fixed coefficients (Leontief [7]). There is substitution via prices between domestic and imported products in the composition of inputs via the constant elasticity of substitution (CES) function. A CES specification also controls the allocation of domestic compost among the various regions. Substitution between capital and labor also occurs in the composition of primary factors through CES functions.

The values of products from a given region sent to another are made up of basic values and trade and transport margins. The share of each margin in the delivery price is a combination of origin, destination, product and source (domestic or imported). Margins on products from one region to another can be produced in different regions. It is expected that the margins will be distributed more or less equally between origin and destination, or between intermediate regions in the case of transport between more distant regions. There is substitution in margin providers according to a CES function.

In the model, there is a representative family for each region, which consumes domestic goods (from the region itself and other regions) and imported goods. The choice between domestic and imported (from other countries) is made by a CES specification (Armington hypothesis [8]). The treatment of household demand is based on a combined CES/Klein-Rubin preference system. Thus, the utility derived from consumption is maximized according to this utility function. This specification gives rise to the linear expenditure system (LES) [9], in which the share of expenditure above the subsistence level, for each good, represents a constant proportion of the total subsistence expenditure of each family.

There is no fixed relationship between capital and investment in the model and this relationship is chosen according to the specific requirements of the simulation. In this case, it is assumed that the growth of investment and capital are identical (PETER et al, 1996). Sectoral exports respond to demand curves negatively associated with

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[6] In a Johansen-type model, the mathematical structure is formed by a set of linearized equations, and the solutions are given by growth rates, that is, elasticities.

[7] The Leontief-type production function is characterized by presenting a fixed relationship between the inputs necessary to produce a specific good or service. This means that the quantity of production is restricted by the quantity of the scarcest input, which is known as the "key input" or "limiting input". The Leontief production function assumes that production is constrained by the input that is available in lesser quantity relative to the other inputs. This implies that it is not possible to increase production without proportionally increasing all inputs, including the limiting input.

[8] Armington hypothesis - goods of different origins are treated as imperfect substitutes

[9] LES is suitable for broad aggregates of goods where specific substitutions are not considered. That is, cross-price elasticities are equal to the income effect given in the Slutsky equation without any contribution from cross-price effects. This implies that all goods are weak complements. The linear spending system does not allow the inclusion of inferior goods (ie, negative income elasticities). It is worth highlighting that tourist goods are examples of non-complementary goods that are perfect and/or have negative income elasticities.

domestic production costs and positively affected by the exogenous expansion of international income, adopting the small country hypothesis in international trade.

There is no theory for the labor market and the relationship between employment and salary is chosen according to the objectives of the simulation. In the typical configuration adopted, national employment is exogenous, implying the endogenous response of the average wage, with fixed sectoral and regional wage differentials. Thus, there is intersectoral and regional labor mobility. Government consumption is exogenous. As there is substitution between the primary factors, labor and capital, the demand for one factor increases in relation to the other factor if its price becomes relatively lower.

TERM - Salvador operates with market balance for all goods, both domestic and imported, as well as in the factor market (capital and labor) in each region. The purchase prices for each of the use groups in each region (producers, investors, households, exports and government) are the sum of the basic values and taxes on sales (direct and indirect) and margins (from trade and transport). Sales taxes are treated as ad-valorem taxes on base flows. Demands for margins (transport and trade) are proportional to the flows of goods to which the margins are connected.

3.2 Database

The TERM - Salvador database was built through a regionalization procedure using as a basis the national model BRIDGE (DOMINGUES et al, 2010) and other models developed at Cedeplar -UFMG (IMAGEM-B in DOMINGUES et al (2009) , BRIDGE in DOMINGUES et al (2009), BLUME in SOUZA (2022)).

The data used in the construction of BRIDGE are derived from the latest Input-Output Matrix (IOM) (2015), estimated from the Resource and Use Tables (TRU) made available in November 2017 by the Brazilian Institute of Geography and Statistics (IBGE) , in addition to a series of other information relating to data from the Annual Social Information List (RAIS), Foreign Trade Secretariat (SECEX) and Regional Accounts System (SCR). Based on data from the national model and various data on regional participation in macroeconomic indicators (GDP, investment, family consumption, government spending, imports, exports), regionalization is carried out.

The regionalization procedure is based on the methodology proposed in Horridge (2006) adapted for the Brazilian case. In this procedure , the following regional *shares are calculated:* GDP by region (including the division between GDP from agriculture, industry, services and public administration), released by IBGE; exports and imports by region in SECEX's ComexStat system; the wage bill (by sector of activity and region) obtained through the “Annual Social Information List” (RAIS) and household consumption (POF). The result is an open model for four regions: the municipality of Salvador, the Metropolitan Region of Salvador (RMS), the rest of Bahia and the rest of Brazil. After the regionalization procedure, the 127 sectors was grouped into 11 sectors, prioritizing activities directly related to tourism.

Tabela 1: TERM model sectors - Salvador[10]

	Model Sectors
1	Land passenger transport
2	Air Transport
3	Accommodation services in hotels and similar
4	Food service
5	Arts, culture, sport and recreation services
6	Other administrative activities and complementary services *
7	Non-Real Estate Rentals and Property Asset Management**
8	Agriculture
9	Industry/Commerce
10	services
11	Public sector

* Travel agencies, Tour operators, Reservation services and other tourism services not otherwise specified
** Rental of means of transport, except cars, without a driver.

TERM – Salvador is the first CGE model that covers not only the metropolitan region of Salvador, but also the municipality of Salvador and the rest of the state of Bahia, bringing improvements both in its theoretical specification and in its database that includes the the most recent and updated in terms of IOM and sectoral data. The model, through its sectoral and regional disaggregation, makes it possible to analyze external policies and events related to tourist activity and dozens of other sectors. In this way, it is possible to capture the impact of political and/or external events on the municipality of Salvador and its metropolitan region in sectoral, regional and macroeconomic terms.

3.3 Closures

For any simulation, the first step is to define the hypotheses of the economic environment in the specific experiment, which is called closing the model. In this case, it is determined which variables must be exogenous and endogenous, that is, the set of variables that remain fixed or receive shocks (exogenous) and the variables resolved internally by the system of equations (endogenous). The number of endogenous variables must be equal to the number of equations in the model. (HORRIDGE, 2011).

In the historical simulation, the behavior of the main macroeconomic aggregates observed in the economy is mimicked, making them exogenous. The historical simulation updates the model up to the period for which data exists, incorporating the changes observed in the components of the macroeconomic dynamics in relation to the base scenario. In other words, it incorporates the observed variations in real GDP, household consumption, government spending, investment and exports. Changes in these observed exogenous variables allow changes in endogenous variables to be measured.

[10]These sectors are described in national accounting as ACT's (Tourism Characteristic Activities)

Tabela 2: Historical Scenario of macroeconomic aggregates, 2016-2020 - Brazil

Macroeconomic Variables	2016	2017	2018	2019	2020
Household consumption	-3.84%	1.97%	2.05%	1.84%	-5.50%
Real investment	-12.13%	-2.56%	3.91%	2.24%	-0.80%
Government consumption	0.21%	-0.67%	0.36%	-0.44%	two%
Export	0.86%	4.91%	3.99%	-2.54%	-1.80%
real GDP	-3.28%	1.32%	1.32%	1.14%	-4.10%
Population growth	1%	1%	1%	1%	1%

From 2016 to 2020 the historical scenario is incorporated and from 2021 to 2100 the projection scenario. In the projections, real GDP is considered to grow at 2.2% per year and government consumption is considered zero until 2030, given the limited growth in government expenses established by the Constitutional Amendment of the Public Spending Ceiling . Furthermore, it is considered that the population grows according to IBGE projection estimates.

Tabela 3: Closing Economic and Demographic Projections, 2021-2100

Projection Scenario	2021 – 2030	2031 - 2050	2051 - 2100
Government consumption	0%*	Endogenous	Endogenous
Real GDP	2.20%	2.20%	2.20%
Population Growth			
Bahia	0.23%	-0.21%	-0.77%
Rest of Brazil	0.59%	0.17%	-0.26%

Source: IBGE
* Constitutional Amendment of the Public Spending Ceiling

When closing the policy (*policy closure*), the target variable of shocks must be exogenized . As the research in question aims to measure the economic impact of a reduction in sectoral activities related to tourism, the variable that represents the level of sectoral activity *(xtot)* had its status changed from endogenous to exogenous through a *swap* with the variable of production productivity *(atot)* . In this way, it will be possible to apply shocks to the level of sectoral activity in accordance with estimates of decreased demand for tourist services (tourist flow x tourist spending), found in the previous phases of the research, using climate impact chains built based on the theoretical framework contained in the 5th Assessment Report (AR5) of the IPCC (IPCC, 2014) and the *Risk Supplement I'm Vulnerability Sourcebook* of the German International Cooperation Agency for Sustainable Development (GIZ, 2017).

Climate impact chains are causal flowcharts that seek to represent a certain socioeconomic system through the chain of its climate threat, exposure and vulnerability factors, contributing to the realization of a certain risk derived from

climate change. Within the scope of this study, the biggest risk researched was the percentage of economic loss for the City's tourism sector, which would be applied as a shock to TERM-Salvador. This percentage was obtained through the quantification and aggregation of factors in the climate impact chain of Salvador's tourism sector, previously prepared through a participatory process. In this calculation, it was possible to arrive at two different risk percentages for each time horizon investigated (Table 3), where: the lowest values are the result of the inclusion of adaptive capacity factors potentially applicable to the destination; and the higher values are the result of excluding these same factors from the climate risk calculation.

The difference between the base scenario, which comprises the historical and projection scenario, in relation to the policy scenario represents, in this simulation, the effect of the shock of a decrease in tourist activity caused by the intensification of climate change. In this case, the model results are presented as the accumulated deviation of a given variable in relation to its accumulated value in the base scenario.

4. SIMULATIONS AND RESULTS

Based on a vulnerability and risk study (GIZ, 2017), it was possible to measure the impact of climate change on tourist flow in the city of Salvador in two different scenarios: Without Adaptive Capacity (NAC) and With Adaptive Capacity (WAC), considering the level of society and community capacity to react and prepare for present and future climate impacts (GIZ, 2017).[11]

These scenarios were constructed through the analysis and interpretation of various threat, exposure, risk and climate vulnerability factors, reaching a final estimate of the decrease in tourist flow in Salvador, in three distinct time frames, 2030, 2050 and 2100. Although there is a consensus among tourism researchers about a general reduction in tourism demand under the effects of climate change, the actual magnitude of this reduction is not easily estimated and this was the most significant challenge of this research.

Tabela 4: Estimates of reduction in Tourist Flow, 2030, 2050 and 2100, by scenarios (In %) - Salvador

Shocks	No Adaptive Capacity (NAC)	With Adaptive Capacity (WAC)
2021 – 2030	27.2%	23.7%
2031 – 2050	29.0%	25.5%
2051 – 2100	30.4%	27.0%

Source: Search results

According to estimates of the reduction in tourist flow, in the period from 2021 to 2030 there will be a 27.2% reduction in the number of tourists visiting the city of Salvador, in a scenario in which society is not prepared to deal with changes climate. Likewise, there will be a decrease in tourist revenue and economic activities compared to an environment without climate change.

[11] As an example, in the case of Salvador, one of the existing capabilities that was considered by the Study was the City's Civil Defense Monitoring and Alert Center, which is very well structured. As a potential capacity, the possible use of Nature-Based Solutions (SBNs) for urban projects developed by the City Hall is mentioned . All the capabilities considered are detailed in the work “50 good ideas for resilient tourism in Salvador” (TRIDELLO, SPINOLA, CISALPINO, 2021).

Based on historical data on arrivals at Salvador airports and Tourist profiles, it was possible to project the variation in tourist demand/revenue using the following formula:

$$D_t = R_t = N_t \, x \, G_t \, x \, P_t$$

On what:
D_t is the tourist demand in year t; R_t is the tourist revenue in year t; N_t is the number of national and foreign passengers who disembarked at Salvador airports in year t (*proxy* for tourist flow); G_t is the tourist's average daily expenditure in year t; P_t is the average stay of tourists in the city of Salvador.

Annual landing data (N_t) has a trend and is not seasonal. Therefore, for tourist flow projections, Double Exponential Smoothing was used with a 95% confidence interval. Once the projections were made, the percentage of decline presented in Table 3 was multiplied, for each year, in each scenario adopted. In this way, tourist flow projections were obtained considering the impact of climate change. Using the historical average of the other variables and inflating the tourist's average daily expenditure variable (G_t), tourist revenue up to 2100 for both scenarios was obtained. The drop in Salvador's tourist revenue, when considering climate change in an SCA scenario, reaches approximately R$400 million reais in 2100, as shown in Graph 1 below.

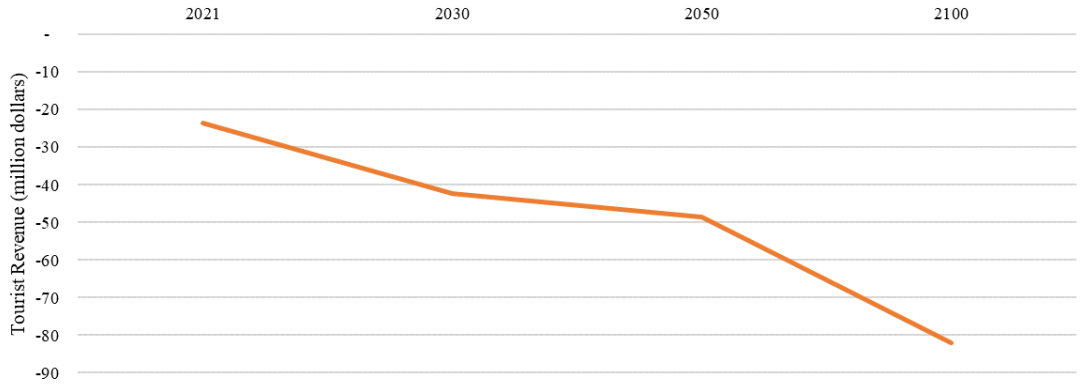

Gráfico 1: Projection of loss of Tourist Revenue in the NAC scenario, 2030, 2050 and 2100 – Salvador
Source: Search results

This loss of revenue directly impacts the economic activity of sectors related to tourism, such as those presented in Table 1. To capture the macroeconomic impact of such a loss in economic activity, a reduction in the economic activity variable (xtot) proportional to the estimates of reduction in tourist flow in Salvador was simulated. This shock was applied to the first seven sectors of the model, which are those directly related to tourism. The results on the main macroeconomic aggregates are shown in Table 4. It is important to highlight that the results are reported as the accumulated percentage deviation in relation to the model's reference scenario and the time frames adopted (2030, 2050 and 2100).

Tabela 5: Accumulated variation in macroeconomic aggregates, NAC scenario, years 2030, 2050 and 2100 - Salvador

Macroeconomic Variables	2030	2050	2100
Municipal real GDP	-2.89%	-6.94%	-12.19%
Employ	-2.58%	-6.25%	-10.97%
Household consumption	-2.59%	-6.28%	-11.01%
Investment	-2.89%	-6.09%	-9.72%
Government consumption	-2.59%	-6.28%	-11.01%
Export	-0.15%	-0.41%	-0.71%
Import	-1.44%	-4.25%	-8.09%

Source: Search results

It is observed that in the No Adaptive Capacity (NAC) scenario, a reduction in the activity of sectors directly related to tourism would result in a drop in all macroeconomic variables, with emphasis on the municipality's real GDP, which would reduce -12.2% in the year 2100. This value indicates that Salvador would obtain accumulated growth -12.2% lower compared to the reference scenario, in the year 2100. In other words, GDP in the municipality would be -12.2% lower compared to a scenario without climate change and its adverse impacts.

It is also noteworthy that the drop in investment is the biggest driver of the drop in GDP, both following the same trajectory. Just as the drop in family consumption is the biggest driver of the drop in imports. Family consumption, employment and government consumption also follow the same trajectory with very similar magnitudes. Exports suffer a less aggressive decrease since Salvador's main export sectors are not those related to tourism.

Aggregate employment follows the same trajectory as GDP, since the growth or decline of the economy implies greater or lesser use of primary factors in production. The reduction in employment, which would reach 10.9% in 2100, suggests that the primary factors of production (land, capital and labor) would become more expensive. The drop in employment would lead to a consequent reduction in family income and consumption, indicating that a decrease in economic activity in the tourism sectors would cause a loss of well-being.

It is worth remembering that from 2030 onwards, government spending is allocated endogenously in the model, before this period these expenses are considered zero due to the Spending Cap policy. It is observed that from 2030 onwards, the declines in macroeconomic variables would become more pronounced. Therefore, an increase in government spending does not imply an improvement in macroeconomic variables, but rather the opposite.

A drop in activity in sectors related to tourism causes the cost of production to increase, this cost is passed on to end consumers through price increases, and through a reduction in sectoral labor, both discouraging consumption. With regard to sectoral variation in employment in the NAC scenario, the air transport sector would present the largest drop in employment, approximately -51% in 2100, followed by the Accommodation Service sectors with a reduction of -47.9%, Art and Culture with -46.5% and Food Service with -45.5%.

In the With Adaptive Capacity (WAC) scenario, a drop in all macroeconomic variables is also observed, but with a slightly smaller magnitude. The GDP of the municipality of Salvador would reduce -11% in 2100 and employment -9.9%, compared to the reference scenario, according to the Table.

Tabela 6: Accumulated variation of macroeconomic aggregates for Salvador, WAC scenario, years 2030, 2050 and 2100

Macroeconomic variables	2030	2050	2100
Municipal real GDP	-2.53%	-6.18%	-11.02%
Employ	-2.26%	-5.55%	-9.89%
Household consumption	-2.27%	-5.58%	-9.93%
Investment	-2.54%	-5.41%	-8.77%
Government consumption	-2.27%	-5.58%	-9.93%
Export	-0.13%	-0.36%	-0.64%
Import	-1.27%	-3.76%	-7.28%

Source: Search results

In relation to employment variation, the Air Transport sector would suffer the biggest drop, as in the NAC scenario, approximately -46.9%. Followed by the Accommodation sectors with a reduction of -43.6%, Art and Cultural Services with -42.2% and Food Services with -41.2%.

The difference in the change in employment in the Accommodation sector would be even more significant, -4.4 percentage points in 2100. In other words, in a scenario with adaptive capacity, jobs in the Accommodation sector would suffer a smaller drop of -9.1 % compared to a scenario without adaptation.

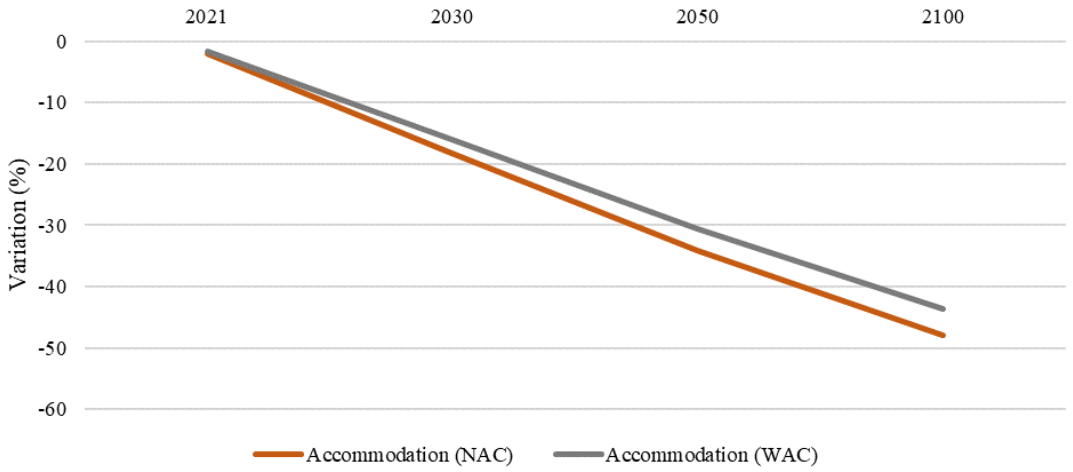

Gráfico 2: Accumulated variation in employment in the Accommodation Service sector, SCA and CCA scenarios, 2030, 2050 and 2100
Source: Search results

Consequently, when comparing the NAC and WAC scenarios, a difference of almost 2 percentage points in the accumulated variation in municipal GDP in 2100 is noted, which is equivalent to a difference of 9.6%.

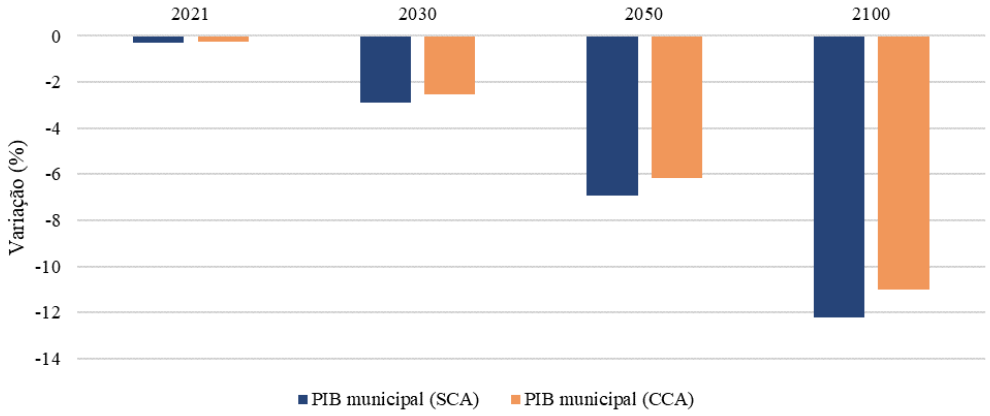

Gráfico 3: Accumulated GDP variation, SCA and CCA scenarios, 2030, 2050 and 2100 - Salvador
Source: Search results

Based on the results, it is possible to estimate the economic value of the impact of climate change on Salvador's economy until 2100. The equilibrium model results in economic losses for Salvador's economy that would reduce the City's potential growth trend. Graph 4 presents the trend and estimated value for Salvador's GDP until 2100 considering the NAC and WAC scenarios. The area of the difference between the two lines is equivalent to the total monetary loss resulting from the effects of climate change on the tourism sector. The sum of the loss over all years is equivalent to 1.4 trillion reais.

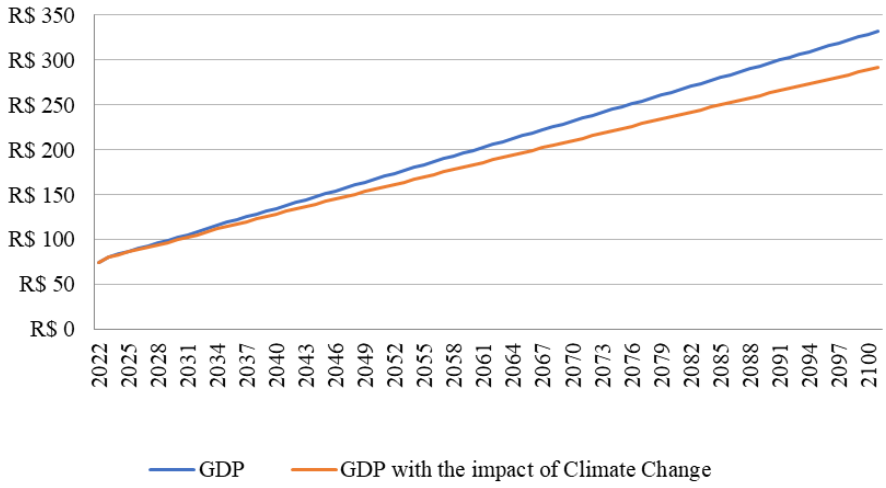

Gráfico 4: Estimates of the economic value of climate change for the economy (In R$ billion) - Salvador
Source: Search results

Table 7 summarizes the annual results for the years 2030, 2050 and 2100. In 2030, the municipal GDP would lose around R$3 billion in one year. With the intensification of impacts, the 2050 GDP would already lose R$11 billion in one year. By 2100, the economic impact would reach R$40 billion in one year.

Table 7: - Estimates of the economic value of climate change for the City's economy (R$ 1,000) - GDP projections to Salvador

Year	Potential	With the impact of Climate Change	Annual value of loss from Climate Change
2030	105,352,035	102,310,790	-3,041,245
2050	170,439,390	158,608,699	-11,830,690
2100	332,168,356	291,645,932	-40,522,423

Source: Search results

5 - FINAL CONSIDERATIONS

From simulations of the impact of reducing tourist demand, through the Computable General Equilibrium (CGE) model, TERM-Salvador, it is observed that climate change, by affecting the performance of the tourism sector, can generate economic and social activities in cities where this activity plays a relevant role in generating employment and income. As shown, the city of Salvador is one of the main tourist destinations in northeastern Brazil. In addition to beach and recreation tourism, the city has flows of historical-cultural, religious, event and entertainment tourism that may also be affected, It is important to outline scenarios about the possible impacts that this economic sector may suffer.

To this end, simulations were carried out, based on a general equilibrium model, in two different scenarios that consider the existence (WAC) or non-existence (NAC) of adaptive capabilities on the part of local society, for the years 2030, 2050 and 2100.

When society is not prepared to deal with climate change (NAC Scenario), estimates point to a reduction in tourist flow, in the period from 2021 to 2030, of around 27.2%. Likewise, the simulations show a decrease in tourism revenue in Salvador by approximately R$400 million in 2100. Still in this scenario, a 12.2% reduction in real GDP in the municipality was noted that same year and a reduction in employment , which reached 10.9% in 2100, suggesting that the primary factors of production (land, capital and labor) have become more expensive. The drop in employment would lead to a reduction in family income, consumption and economic activity in the tourism sectors, which, consequently, would cause a loss of well-being. The air transport sector was the one that showed the biggest drop in employment, followed by the Accommodation Service, Art and Culture Service and Food Service sectors. With regard to economic losses, it is estimated that they could reach R$40 billion in the year 2100 and, if the entire period studied is considered, accumulate an amount of R$1.4 trillion.

In the second scenario, which considers society's adaptive capacity (WAC Scenario), a drop in all macroeconomic variables was also observed, but with a slightly smaller magnitude. Employment would be reduced by 9.9% and the GDP of the municipality of Salvador by 11% in 2100. This result can demonstrate that When society is prepared to deal with climate impacts, the loss of well-being is less than a society without the capacity to react.

Climate change is inevitable, as are its consequences. The development of a more resilient tourist activity involves building a more resilient city and society. In the specific case of Salvador, the study that gave rise to this article listed 51 adaptation

measures capable of reducing the impacts of climate change and expanding the city's adaptive capacity. These are alternatives with different levels of complexity and opportunity cost that, for their implementation, depend on a broad awareness of the risks faced by the sector and the articulation of municipal administration, trade, academia and civil society in an action joint effort that seeks to reduce expected impacts.

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