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VULNERABILITY AND RESILIENCE ASSESSMENT OF COASTAL TOURISM DESTINATIONS TO CLIMATE CHANGE: DEVELOPING AND APPLYING THE COASTOURD INDEX TO BALNEÁRIO CAMBORIÚ – BRAZIL

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DEFESA FINAL DE TESE DE ERICK DA SILVA SANTOS
BANCA Nº073/2022 REG 144290/2017

No dia 29 de março de 2022, as 19h00min, por teleconferência, o(a) aluno(a) mencionado(a) acima defendeu seu trabalho final (apresentação oral seguida de arguição) perante uma Banca Examinadora, cujos membros estão listados abaixo. O(A) aluno(a) foi APROVADO(A) pela Banca Examinadora, por unanimidade, em cumprimento ao requisito exigido para obtenção do Título de Doutor em Ciência do Sistema Terrestre. O trabalho deve incorporar as correções sugeridas pela Banca Examinadora, a critério e sob revisão final do(s) orientador(es).

Título: "VULNERABILITY AND RESILIENCE ASSESSMENT OF COASTAL TOURISM DESTINATIONS TO CLIMATE CHANGE: DEVELOPING AND APPLYING THE COASTOURD INDEX TO BALNEÁRIO CAMBORIÚ – BRAZIL"

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*"**Great minds discuss ideas**; average minds discuss events; small minds discuss people".*

Eleanor Roosevelt

To all of my ancestors, starting by my parents João e Valnadete, grandparents, great-grandparents, and the others that by tracking their pathways allowed my existence. Today, the first Doctor amongst so many past generations.

A todos os meus ancestrais, iniciando pelos meus pais João e Valnadete, avós, bisavós e demais, que pelo trilhar de vossos caminhos permitiram minha existência. Hoje, o primeiro Doutor entre tantas gerações pretéritas.

(In Portuguese)

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ABSTRACT

Tourism has been one of the greatest social phenomena of the current century. Almost 1.5 billion international visitors travelled around the world in 2019. However, climate change impacts have been widely recognized as a threat for tourism because several tourism activities rely on climate and nature-based resources such as ski tourism, ecotourism, and beach tourism. Climate projections expect that extreme natural events will increase in frequency and intensity, triggering flash floods, landslides, blown belongings, as well as water shortages. These events negatively affect coastal destinations by inundating and eroding beaches, reducing attractiveness for beachgoers because of sequential days of rainfall, decreasing the spatial area for sunbathing, and causing many other impacts. Several studies have assessed vulnerability and resilience of communities and their settlements by addressing specific components of the tourism system such as economic, mostly applying qualitative methods. Only a few studies analyse in a broader perspective, whereby the approach looks at the whole tourism system rather than specific components, but they lack the quantitative focus. In this context, this thesis aims to develop a generic and novel framework that combines qualitative-quantitative approaches to create an index to assess the vulnerability and resilience of coastal tourist destinations to climate change at a destination level, focusing on the whole tourism system. The method consisted of a comparative analysis of several frameworks to find the most suitable one to guide the creation of the assessment tool. As a result, 55 indicators have been suggested to compound the nine dimensions of the Coastourd Index. To validate the tool, the index was applied in the Brazilian destination of Balneário Camboriú, a coastal tourism city that attracts 1.5 million visitors only in the summer. The proposed novel and generic Coastal Tourist Destination Vulnerability and Resilience Index to Climate Change (Coastourd) proved to be a promising tool to help coastal destinations worldwide to map out the factors that cause vulnerability (constraints) and increase resilience (opportunities) in the face of a changing climate.

Keywords: Vulnerability and resilience. Coastal tourist destinations. Climate change. Qualitative-quantitative approach. Coastourd Index. Balneário Camboriú, Brazil.

AVALIAÇÃO DE VULNERABILIDADE E RESILIÊNCIA DE DESTINOS TURÍSTICOS COSTEIROS ÀS MUDANÇAS CLIMÁTICAS: DESENVOLVENDO E APLICANDO O ÍNDICE COASTOURD EM BALNEÁRIO CAMBORIÚ - BRASIL

RESUMO

O turismo se mostra como um dos maiores fenômenos sociais do século atual. Quase 1,5 bilhão de visitantes internacionais viajaram ao redor do mundo em 2019. Entretanto, os impactos das mudanças climáticas se tornam cada vez mais reconhecidos mundialmente como uma ameaça para o turismo. Isso porque várias atividades turísticas dependem de recursos climáticos e naturais, como turismo de esqui, ecoturismo e turismo de praia. Os cenários de projeções climáticas mostram que os eventos naturais extremos devem aumentar em frequência e intensidade, provocando inundações repentinas, deslizamentos de terra, vendavais, bem como escassez de água. Esses eventos afetam negativamente os destinos litorâneos, inundando e erodindo praias, reduzindo a atratividade para os banhistas devido aos dias sequenciais de chuvas, diminuindo a área espacial para banhos de sol e causando muitos outros impactos. Vários estudos têm avaliado a vulnerabilidade e a resiliência de comunidades e seus locais de sobrevivência, focando em componentes específicos do sistema de turismo tal como o econômico, utilizando métodos qualitativos. Poucos estudos analisam em uma perspectiva mais ampla, em que a abordagem contempla todo o sistema turístico e não somente componentes específicos, contudo carecem do enfoque quantitativo. Neste contexto, esta tese visa desenvolver um modelo genérico e inovador que combine a abordagem qualitativa-quantitativa para criar um índice de avaliação da vulnerabilidade e resiliência dos destinos turísticos costeiros às mudanças climáticas em um nível local e com foco em todo o sistema de turismo. O método consistiu na análise comparativa de vários modelos para encontrar o mais adequado para orientar o desenvolvimento da ferramenta de avaliação. Como resultado, 55 indicadores foram sugeridos para compor as nove dimensões do Índice Coastourd. Para validar a ferramenta, o índice foi aplicado no destino brasileiro de Balneário Camboriú, cidade turística no litoral de Santa Catarina que atrai cerca de 1,5 milhão de visitantes apenas no verão. O novo e genérico Índice de Vulnerabilidade e Resiliência de Destinos Turísticos Costeiros às Mudanças Climáticas (Coastourd) provou ser uma ferramenta promissora para auxiliar destinos costeiros ao redor do mundo a mapear os fatores que causam vulnerabilidade (limitações) e aumentam a resiliência (oportunidades para adaptação) diante de um clima em constante alteração.

Palavras-chave: Vulnerabilidade e resiliência. Destinos turísticos costeiros. Mudanças climáticas. Abordagem qualitativa-quantitativa. Índice Coastourd. Balneário Camboriú, Brasil.

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LIST OF ACRONYMS

AA	Adjustments & Adaptation
AD	Anno domini (after Christ)
BC	Balneário Camboriú
BCE	Before current era
BioE	Biophysical & Environmental
BuiE	Built environment
CC	Climate change
Coastourd	The Coastal Tourist Destination Vulnerability and Resilience Index to Climate Change
DMO	Destination marketing organization
DRR	Disaster risk reduction
DSF	Destination Sustainability Framework
ENEs	Extreme natural events
EP	Emergency plan
ES	Economic & Social
GDP	Gross Domestic Product
GS	Governance System
IBGE	Instituto Brasileiro de Geografia e Estatística (Brazilian Institute for Geography and Statistics)
ICR	Impact and Coping Responses
ICT	Information and Communication Technologies
Pop	Population characteristics
SC	Santa Catarina
SES	Socio-ecological system
SLR	Sea level rise
SS	Shocks & Stressors
TEF	Tourism Ecosystem Framework
TS	Tourism-specific sensitivities
UNEP	United Nations Environment Programme
UNWTO	United Nations World Tourism Organization
VUL/RES	Vulnerability and resilience

WTTC World Travel & Tourism Council

CONTENTS

1 INTRODUCTION

Tourism plays an essential role in the global economy. It represents 7% of total global exports, 28% of services exports, 10% of the global GDP, and one in ten jobs created on the planet. The international tourism flow has achieved 1.4 billion visitors by the end of 2019 (before the Covid-19 pandemic), accounting for approximately US$1.48 trillion (UNWTO, 2021; WTTC, 2021). These numbers overpass traditional industries such as the automobile, accounting for 3% of global GDP. Despite solid numbers, tourism is very vulnerable to several global issues such as wars, urban violence, diseases, and natural disasters intensified by climate change (CC). Beach-, nature-, and snow-based tourism are the most dependent on climate, making CC a threat for tourism because longer-term variations are expected, such as warmer temperatures that reduce snow cover for ski destinations, shifts in precipitation that intensify rainfall, windstorms, droughts, and other extreme events (for example storm surges), and cold- heat waves that cause thermal stress (AMELUNG; NICHOLLS, 2014; BIGGS et al., 2015; IPCC, 2022; SCOTT et al., 2016; SCOTT; GÖSSLING, 2015; SIMPSON et al., 2008; UNEP, 2008). Controversially, tourism also intensifies these events by responding to approximately 5% of global CO2 emissions (UNEP, 2008).

Some destinations are already facing impacts and struggling to adapt to the ongoing changes (DA SILVA SANTOS; MARENGO, 2020; DE URIOSTE-STONE et al., 2015; PERCH-NIELSEN, 2010; ROSSELLÓ; BECKEN; SANTANA-GALLEGO, 2020; RUTTY et al., 2017; SEEKAMP; JURJONAS; BITSURA-MESZAROS, 2019). These impacts are caused by flash floods, landslides, as well as water and energy shortages, affecting urban centres that serve as major tourist destinations by reducing attractiveness, which leads to a loss of revenue (BECKEN, 2013; IPCC, 2014, p. 557; SANTOS-LACUEVA; CLAVÉ; SALADIÉ, 2017; SCOTT; GÖSSLING; HALL, 2012). In addition, cold-heat waves also affect people's health by increasing the risk of hypo- and hyperthermia, and hurricanes can produce inundation and associated hazards – including injuries and risk of death – impacting livelihoods as well as

destinations image, which reduces tourism flow (IPCC, 2014, p. 720; SCOTT; GÖSSLING; HALL, 2012).

Marine and coastal areas face extra challenges due to sea-level rise (SLR). These areas have high socioeconomic value for recreation, tourism, and ecosystem services, e.g., seafood and habitat provision (BARBIER et al., 2011), and are amongst the most important for destinations because coastal tourism is the largest market segment of global tourism (MORENO; BECKEN, 2009; RUTTY; SCOTT, 2014) with more than half of travellers worldwide (57%) choosing beach destinations for their holiday (TRIP ADVISOR, 2016). Over 60% of Europeans participate in marine activities, and more than 80% of US tourism receipts are generated by beach tourism (IPCC, 2014, p. 384). However, coastal destinations are of significant vulnerability to CC, specifically, those places in which sun, sand, and sea are the main attraction since almost half of the world's sandy beaches are under threat of extinction by the end of the century (see VOUSDOUKAS et al., 2020).

The main factors that directly impact coastal destinations are (1) SLR (that inundates and erodes beaches); (2) sequential days of rainfall (not attractive for beachgoers); (3) sand strip thickness (spatial reduction for sunbathing); (4) extreme meteorological events (frighten beachgoers); (5) thermal stress (causes discomfort and risk to health); and (6) biodiversity loss (attractions such as coral reefs and whale, dolphin and birdwatching) (PERCH-NIELSEN, 2010). Marzeion; Levermann (2014) identify that 6% (40 out of 720 sites) of the UNESCO World Heritage sites worldwide might be affected by SLR even without a world mean temperature increase, whereas 19% (136 sites) would be impacted under a 3 ºC warming. Most World Heritage sites are tourist destinations, and some are among the most iconic places on the planet (UNESCO; UNEP, 2016), including the statues of Easter Island (Chile), the Statue of Liberty in New York (USA), the Sydney Opera House (Australia), and the Rio de Janeiro Landscape (Brazil).

Vulnerability and resilience (VUL/RES) have routinely been used to assess such risks for communities and cities (HALL et al., 2015; IPCC, 2014), with

predominance focus on qualitative issues. The qualitative nature of these assessments provides actors with the in-depth knowledge needed to inform effective solutions that are targeted, contextual, and nuanced. However, qualitative assessments do not provide as accurate and precise information as quantitative assessments, which is needed to justify decision-maker's actions in the first place (CLARK-GINSBERG et al., 2020; COX; HAMLEN, 2015; PERCH-NIELSEN, 2010). Similarly, much of the existing literature in tourism focuses on the qualitative analysis of the system (BECKEN, 2013; BIGGS; HALL; STOECKL, 2012; CALGARO; LLOYD; DOMINEY-HOWES, 2014; HOPKINS, 2015; JAMALIAH; POWELL, 2019; LOEHR, 2020; STUDENT; LAMERS; AMELUNG, 2020). Some researchers combine qualitative and quantitative methods, but they address few components (e.g., economic, social) of the overall system (DOGRU et al., 2019; DOGRU; BULUTT; SIRAKAYA-TURK, 2016; PERCH-NIELSEN, 2010; SANTOS-LACUEVA et al., 2019). Only few studies analyse in a broader perspective, whereby the approach look at the whole tourism system rather than specific components, but they lack the quantitative focus (BECKEN, 2013; CALGARO; LLOYD; DOMINEY-HOWES, 2014; LOEHR, 2020; MORENO; BECKEN, 2009).

There is an evident lack of VUL/RES studies within the field of tourism which integrate quantitative analysis with qualitative data, causing Luthe; Wyss (2016) to call for a validation of metric interpretations, which are "paramount on the (long) path to a more integrative approach towards the understanding of (complex) tourism resilience" (LUTHE; WYSS, 2014, p. 162). Becken (2013) adds that research in tourism needs to advance the meaningful integration of qualitative and quantitative data for understanding interactions at multiple scales, plurality of values and worldviews, resilience trade-offs, and power relations. For Scott; Hall; Gossling (2019) the regional assessment impacts of CC on tourism should consider the wide range of potential impacts and their interactions at a destination scale. The IPCC (2014, p. 395) report identifies two research gaps: i) the assessment of VUL/RES of coastal destinations to specific impacts, which includes tourists' perceptions to projected climatic change; and

ii) the understanding of socioeconomic and biophysical contexts, covering institutional arrangements that shape effective governance of coastal areas.

To address all these gaps, the overall objective of this thesis is to develop a generic and novel index to assess the VUL/RES of coastal tourist destinations to CC at a destination level, focusing on the whole tourism SES. Hence, the main goals are:

1. To create a methodology able to help coastal destinations map out the factors that cause vulnerability (constraints) and increase resilience (opportunities) in the face of a changing climate.
2. To combine a qualitative-quantitative method that measure each of these factors to provide accurate information for policymakers and other tourism stakeholders to support better decisions and actions.
3. To integrate stakeholders' perceptions, including tourists, into the assessment tool.
4. To apply and validate the index methodology by assessing a Brazilian destination.
5. To contribute to reduce the literature gap in South America in the field of tourism and climate change.

To achieve these goals, the thesis is structured in four more chapters. Chapter 2 describes the understanding of tourism development and its related concepts that are important to define limits and frame the focus on the object under investigation. Therefore, it discusses the episteme of tourism and conceptualizations. Chapter 3 deeply explores the literature to compare and find the most suitable framework that is used to develop the novel methodology to create the index that embeds qualitative-quantitative approaches. Chapter 4 consists of two parts. The first contains the data collection and related results based on the framework developed in Chapter 3. The second one presents the results of applying the index in the Brazilian destination of Balneário Camboriú. Finally, chapter 5 concludes the thesis by presenting the significant findings, the research limitations, and the opportunities for future research.

2 FUNDAMENTS OF TOURISM

Understanding the roots of tourism science and related concepts are fundamental for tourism research because conceptualization determines the problems addressed, shape methodology and research design (impacting on an interpretation of findings), and influence its applicability since it defines the focus, therefore, the priorities and where solutions might be found (PEARCE, 2014). Tourism is transdisciplinary by nature because it is about places and spaces that are embedded in culture, economy, technology, policy, and the social lives of communities within their natural environment, all of which are encapsulated in the visitors' experience at a specific period on time (BENI; MOESCH, 2017). Tourism comprises the individual's experience in the exact moment of perceiving an "object" be there a place, landscape, culture, nature, or any other type of experience. The consciousness gives significance to the objects (BENI; MOESCH, 2017; TRIBE, 2009). Some paintings cost millions of dollars not because of the materials they are made of, but the intangible value. Therefore, the foundations of tourism build upon the core of the human evolution, including all its socio-cultural behaviours that have set different meanings for similar objects along centuries.

2.1 Human-tourism evolution

The origin of tourism is intrinsically associated with the evolution of humankind. The species has been dislocating from place to place since ever, and for many reasons, such as finding food, shelter, avoiding predators, or even discovering new territories. Some authors consider the origin of tourism back in the Industrial Revolution (BARRETTO, 1995; BENI, 1998; TRIGO, 1998). However, Table 2.1 presents a four-phase chronological thinking of tourism development based on researchers whose approaches start from the ancient Greece and Egypt (AMARAL JUNIOR, 2008; NAKASHIMA; HUERTAS CALVENTE, 2016; RAMOS; COSTA, 2017).

It is clear from human history that dislocation has existed in different societies since ancient times. Technology in transportation, communication, lodging, and

arrangements on the social organization also established the foundations for the current tourism development. The Ancient Age phase had the first stimulus for regional displacement in Egypt and Greece. The Grand Tours across Europe marked the Intermediate phase, and thanks to technological advances (e.g., the compass), the Great Navigations disembarked in several parts of the globe. The Industrial or Modern phase faced social revolutions that changed the work conditions and instituted the free time paid. Such improvements in the standard of living – associated with the emergence of a middle class with available capital and transportation development – made the travels for educational/cultural and leisure purposes famous. These travels stimulated the construction of recreational and holiday centres, which led to the organization of traveling groups.

Table 2.1 – Tourism evolution phases.

Phases of Tourism	Historical Events
Ancient Age (2700 BCE - 873 AD)	• The Egyptian pyramids instigated population's curiosity and beliefs around 2700 BCE. • The Olympic Games in ancient Greece attracted thousands of people. • Thermal treatments gave rise to bath inns. • The Roman Empire entertained thousands of people with the gladiators. • The Guidebook of Greece, considered the oldest travel guide in the history, is due about 160-180 AD. • Christians pilgrimed to Jerusalem and Rome after Jesus Christ's death. • From the 6th century on, Mecca became a compulsory destination for Muhammad followers. • In 813 Santiago de Compostela became a destination for pilgrimages after the St. James' tomb discovery.
Intermediate Age (1200-1700)	• Scientific and technological advances, such as compasses, astrolabe, and rudder contributed to navigation development (13th century). • Major trips to China and then the Americas took place from the 15th century on. • The Grand Tours to cultural places complemented the education of wealthy families' children in Europe in the 17th century. • The thermal spa resorts in England became a leisure option.
Industrial or Modern Age (1750-1945)	• The Industrial Revolution boosted the urban expansion, creating new social demands such as leisure. • Transport system developed considerably in Europe and USA with railways expansion as well as with comfortable cabins in

(*continued on next page*)

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	ships for long trips. • Student trips among young people for cultural purposes (museums, theatres, libraries, archaeological sites, etc.) became popular in Europe. • Job regulation allowed free and paid time. • Sea baths for curing purposes in the 18th century evolved to recreational resorts in the 19th century. • In 1841 Thomas Cook organized the first trip in the same business model of the current travel agencies. Years later he created the hotel coupon (the voucher). • Atlantic City (USA) emerged as a place for vacations (tourism), receiving more than half million visitors a year in the 1870s. • Graham Bell created the telephone in 1876, revolutionizing the telecommunications. • The automobile was invented in 1908 and the bus in 1921, establishing new trends for trips/tourism. • The aviation development started in the early 20th century. • The two World Wars in the first half of the 20th century produced a suppressed demand for travel.
Contemporary or Postmodern Age (after 1945)	• The world enjoyed new technologies in communication, aviation and navigation after the period of the two Great Wars. • Jumbo airplanes for 400 passengers and 1000 km/h speed were built. • Massive tourism intensified in the 1960s and 1970s in almost whole world. • The World Tourism Organization was founded in 1975. • The increase of cities and the demographic explosion required new needs such as leisure and recreation. Brazil promulgated rights to leisure in its 1988 Federal Constitution. • Tourism acquired economic expressiveness at a global scale in the turn for the 21st century. • The advancing of the global environmental awareness (1992 Rio Summit) recognized tourism as a potential tool to conserve nature. • Climate change became perceived worldwide and launched scientific discussions in the tourism field. • The UN set tourism as a driver for many Sustainable Development Goals achievement. • Socio-digital networks reduced the distances and started to influence destinations' choice, creating fetishisms in tourism. • Smartphones gave rise to specialized applications for tourism (lodging, ticketing, etc.), facilitating the access to information and to the "tourism product". • New lodging systems emerged as an alternative to the traditional hotels and lodges to attend those who search for local experiences such as lodging platforms that allow staying in locals' houses or even exchanging houses.

(*finished*)

Adapted from: Amaral Junior (2008), Nakashima; Huertas Calvente (2016), and Ramos; Costa (2017).

Table 2.1 summarizes the societies' evolution in which we find the basis of the social practice of travelling, therefore, the tourism. The need for leisure, natural or urbanized places, or even the wish to learn from different cultures or experience the exotic became possible due to technological innovations that generated a promising tourism operationalization. Communication technologies also boosted accommodation platforms that offer lodging with residents to visitors who search for experiencing local costumes at destinations, expanding new sociocultural values: appreciation of popular culture instead of only erudite one. Such expansion in tourism triggered academic studies in the early 20th century when different schools initiated debates to understand and explain the dynamics of this social practice called tourism.

2.2 Concepts and episteme of tourism

The literature shows that the word "*tour*" emerged firstly in 1760 in England to designate the idea of a round-trip (MOESCH, 2002). However, despite the considerable number of travellers in Europe and the USA after the 1800's, the studies about the new phenomenon of so-called tourism only originated at the end of the 19th century. On the 24th of August 1895, the Swiss Society of Hoteliers published the Essay "Contributions to a statistics of tourism in Switzerland" written by Guyer-Freuler (1895). The author shared concerns about statistical methods to identify whether the revenues in Swiss transports and hotels originated either from foreigners or nationals. That was economically important for planning the business for growing demand, especially for the Alps, so that in 1902 Adolf Brougier delivered a speech about the impact of tourism for Bavaria region (Germany) where he described tourism as leisure travel, highlighting the several direct and indirect positive effects on the local economy such as the beer consumption increase (DANN; PARRINELLO, 2009).

In another publication, Guyer-Freuler (1895) defined tourism as a singular phenomenon of modern time, which depends on the people's need for change and relaxing; the belief that recognizing nature, art, and landscapes bring happiness to human beings; and the wish of helping nations and communities to approach to each other, thanks to the developments in commerce and

industry as well as communication and transportation. In the same year of 1905, the Austrian economist Josef Stradner published a book regarding the economy of tourism in which he stated that “tourism is a business of travel, a professional activity that arises from the transport of luxury travellers”. Stradner continues by saying that tourism in the strict sense “drives the needs of culture, intellectual life, the spirit, health and celebration, which are related to the subjective preferences linked to the messages of ideal nature” (LOHMANN; PANOSSO NETTO, 2017, p. 27).

Discussions to define tourism mark the beginning of the 20th century. The Austrian and German schools have opened the studies about a conceptualization of tourism. Barreto (1995) states that the first concepts focused only the economic aspects in the process of arrival, stay, and departure of visitors. In 1929, German schools introduced the principle of displacement, adding to the concept the idea of traveling to places other than the visitor’s permanent residence, excluding the place where they work. Years later, the same scholars discussed the social implications of the temporary relationship between residents and non-residents for reasons of personal satisfaction and pleasure (BARRETTO, 1995). In 1942, studies in Switzerland included an essential factor into the concept: the interrelations that produce phenomena during the visitor’s displacement and stay (BENI, 1998) such as a rapid and momentaneous increase in the destination’s population. In the 1970s, Spanish and American schools incorporated into the definition the economic and socio-environmental implications. These are the negative and positive impacts (JAFARI; BRENT RITCHIE, 1981).

Panosso Netto (2009) considers the following definition as the most complete one:

> A human intentional activity that serves as a mean of communication and as a link of interaction between the peoples, inside a country or even beyond its geographical demarcations. It involves the temporary displacement of people from one region to another, country or even continent, with the objective of satisfying necessities and not the realization of remunerated activity. For the visited country, tourism is an industry whose products are consumed in loco, producing invisible exports (PANOSSO NETTO, 2009, p. 45).

The World Tourism Organisation (UNWTO) has a global relevance in tourism. As so, concepts, terms, and definitions generate significant impact worldwide, reason why the organisation remains under constant critique. For example, the statistical methodology guidebook considers as an international tourist those who are in transit (connection) to an ultimate destination, an issue still unsolved. However, after a long critique period, UNWTO changed the concept of tourism, stating that

> tourism is a social, cultural and economic phenomenon which entails the movement of people to countries or places outside their usual environment for personal or business/professional purposes. These people are called visitors (which may be either tourists or excursionists; residents or non-residents) and tourism has to do with their activities, some of which involve tourism expenditure (UNWTO, 2020)

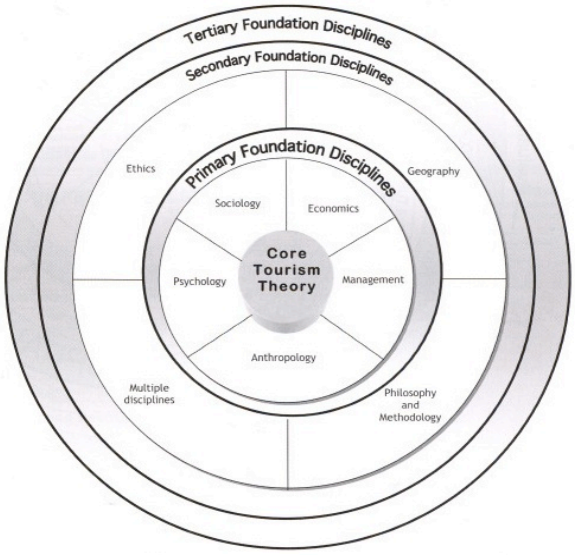
This research adopts the ideas of Moesch (2002), who refers to tourism as a social practice packed with complex interrelationships in the process of production-consumption, underpinned on cultural and historical heritage. These practices can be portrayed in a form of a socio-ecological system and take place within a diverse environment (including natural areas), dynamic sociocultural interaction, social relations of hospitality and cultural exchange, synthesised in the form of the “tourism product” and consumed by millions of people.

2.2.1 Tourism as a science

Debates around tourism as a science have been challenging the tourism studies ever since. For Ritchie et al. (2008) there are two mainstreams in this debate. The first regards to the applied research, related to the “management of tourism”. Countries seeking for economic development, whereby tourism responds for a high foreign exchange rate, require studies about planning & management, marketing & communication, hospitality, transportation, tourism product, sustainable tourism, etc. The second relates to the “science of tourism”, which focuses on the theoretical and epistemological issues of tourism as a new science. Jafari; Ritchie (1981) listed 21 areas of knowledge and their respective disciplines that produce specific knowledge in tourism. Leiper (2000)

had advocated for tourism as a science by claiming that tourism presents theories and methods applied only to the tourism phenomenon. For instance, he justifies that the multiplier effect theory emerged from analysing the economic impact of tourism on the distribution of visitors' expenditure. These studies motivated Ritchie; Sheehan; Timur (2008) to propose a conceptual framework of disciplines that form the foundational basis for tourism theories, essential for the consolidation of a science. The authors classified the disciplines into three hierarchies: primary, secondary, and tertiary (Figure 2.1).

Figure 2.1 – Conceptual framework of the core-foundational tourism theory and its relationship to primary, secondary, and tertiary foundation disciplines.



Source: Ritchie; Sheehan; Timur (2008).

For Beni and Moesch (2017) the object of tourism studies is an object under construction; it is not a constructed one. As observed in its socio-historical evolution, the phenomenon presents dynamic roots driven by social practices. From this perspective, tourism can be understood as a social phenomenon beyond purely economic understanding; it also includes cultural and social aspects, natural environment, and the means of production. Then, tourism is formed by a set of elements whose focus cannot be limited to only one; instead, it results from a complex interrelation between such elements. Drawing upon these collective challenges, researchers and academic journals postulated a different perspective by introducing a system approach for tourism, changing the dominant paradigm of analysing the phenomenon from only one

perspective. Panosso Netto; Nechar (2014) briefly discuss the epistemological schools of tourism, including the systemic one:

a) Positivist: it denies tourism as a science because it does not follow the levels of classical science. It classifies tourism as a strand of other sciences.

b) Systemic: general systems theory is the pillar of tourism studies, wherein the components harmonically interact to achieve a common goal. The system presents properties that would not be possible at the element level, being more the sum of its parts.

c) Marxist: it recognises tourism as a new way of imperialism and colonialism in which wealthy societies impose their needs on the poorest.

d) Phenomenological: it seeks to understand the dynamism of human experience tried by individuals at a specific space and time.

e) Hermeneutics: try to interpret tourist facts through reading, rereading, and providing new interpretations of tourism concepts.

The systemic school is the most widespread approach in Lantin America, especially in Argentina, Brazil, and Mexico. It is also world widely accepted in the sustainable tourism field and environmental sciences, which includes the research focus of this study: climate change and tourism. Therefore, a deeper discussion about the system theory is provided next.

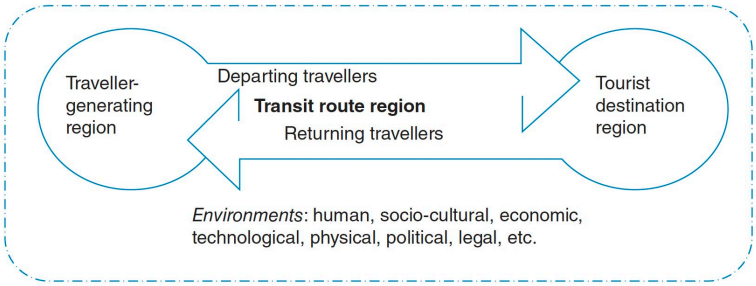
2.2.2 The tourism system

System thinking emerged in the mid-twentieth century in biology from the ideas of the Austrian Ludwig von Bertalanffy. In the study of organisms, von Bertalanffy (1968) contested that an organism was the result of the simple sum of its parts. Instead, he stated that an organism results from all parts that form it and the interactions and properties that emerge from these interactions. This theoretical standpoint formed the basis for general systems theory (GST), which contends that a system cannot be understood from the isolated study of its parts; it must consider the complex and nonlinear interactions between the parts

and the patterns that emerge from these connections (VON BERTALANFFY, 1968). GST has been primarily applied in social sciences to explain processes in the human system and was later coupled to the natural system by the end of the last century (BERKES; FOLKE, 1998), giving rise to the concept of social-ecological system (SES). An SES is an integrated system of multiple subsystems – ecosystems and human societies – with interdependencies and reciprocal feedback loops (BERKES, 2007; FOLKE et al., 2010). These multiple subsystems have multiple internal variables (components) that function at multiple levels - analogous to organisms composed of organs, organs of tissues, tissues of cells, and cells of proteins (OSTROM, 2009).

Based on the system thinking, Leiper (1979) introduced the first tourism system framework internationally recognised (Figure 2.2), which included five components: (i) the traveller generating region; (ii) a transit region that connects the origin to the destinations; (iii) the tourist destination region; (iv) the tourist; and (v) the tourism and travel industry. Leiper's framework seemed seminal and too simple to present a new paradigm and advancement of the tourism science since it excluded several elements that are also part of the tourism system. In his framework, the five elements influence and are influenced by 'external' factors such as cultural, social, economic, political, and technological. However, such factors (e.g., natural and cultural) should be consider as part of the system since they provide the core attractions for tourists, i.e., natural landscape, beaches, cultural festivals, historical buildings, etc.

Figure 2.2 – Leiper's tourism system framework.



Source: Leiper (1979).

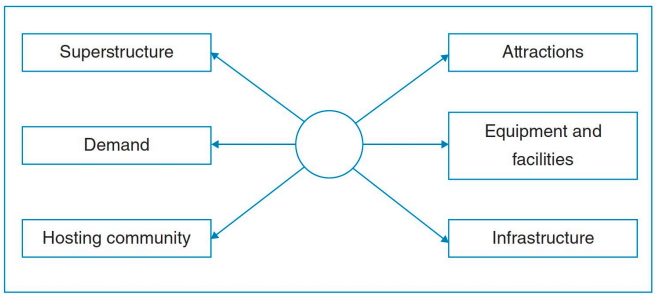
In Latin America, the tourism system framework proposed by Molina (1991) became well known within the academia. In Molina's view of the tourism system

(Figure 2.3), a set of parts or subsystems interact to achieve a common goal. These subsystems are the:

1. Superstructure (public and private sector organizations, laws, regulations, plans, and programmes).
2. The demand (tourists living in the country and abroad).
3. The infrastructure (airports, roads, water supply networks, sewage, telephones, etc.).
4. The attractions (natural and cultural).
5. The equipment and facilities (hotels, motels, campgrounds, trailer parks, restaurants, cafes, travel agencies, pools and tennis courts, among others).
6. The hosting community (local residents directly and indirectly linked to tourism).

Molina's framework includes many elements that compound the tourism system, but it fails to capture interconnections and relationships amongst internal elements and does not explain the foundations of systems theory.

Figure 2.3 – Molina's tourism system framework.

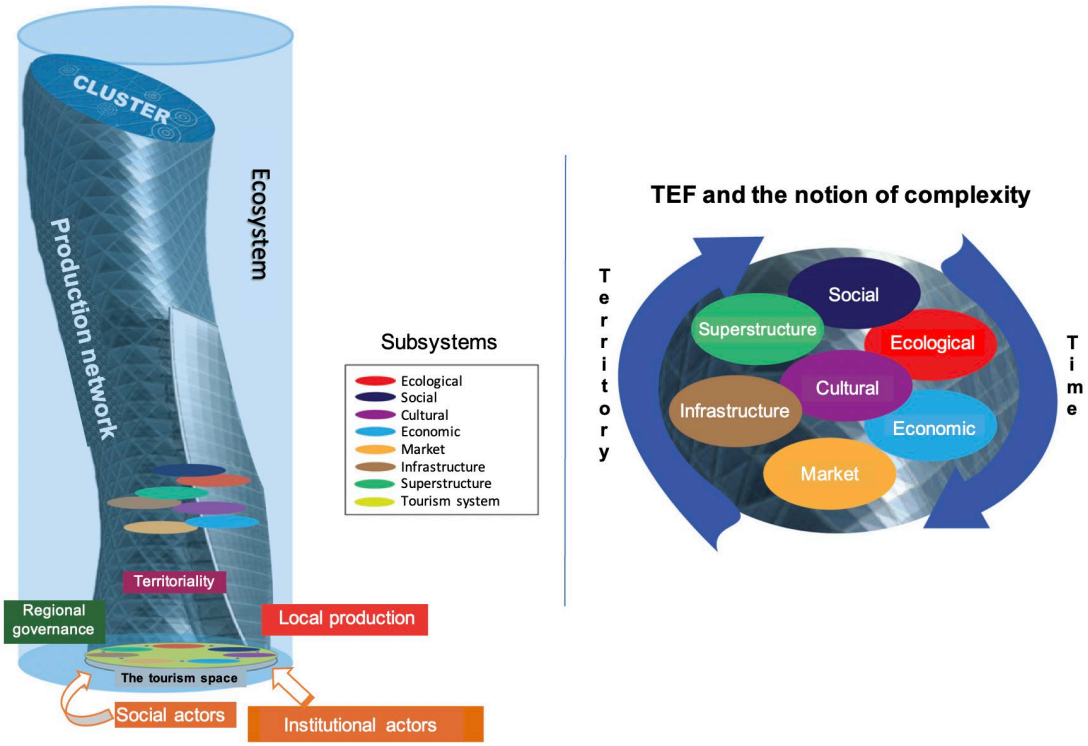


Source: Molina (1991).

In Brazil, professor Beni (1998) developed a tourism system framework whose first model approach compartmentalised the tourism system's interactions and relationships. Two decades later, Beni and Moesch (2017) revised the framework to incorporate Morin's (2007) observations on complexity thinking, originating the Tourism Ecosystem Framework (TEF), shown in Figure 2.4. This framework considers tourism as a living system, where all the components (parts) are interconnected through a network production; the whole tourism

ecosystem exists as a unique entity integrated into the natural ecosystem (BENI; MOESCH, 2017). Humans (the social dimension) have settled down near water resources (the ecological dimension) for millenniums, and both are autonomous systems. However, they are also interconnected, originating the principle of retroactive circularity (MORIN, 2007) whereby interventions in the ecological system consequently interfere in the organisation of society itself, that is, the social system. By applying these principles, Beni and Moesch (2017) capture all the elements and complex interactions that take place in the tourism ecosystem, which comprises seven subsystems (summarized in Table 2.2): cultural, ecological, economic, social, market, infrastructure, and superstructure.

Figure 2.4 – The Tourism Ecosystem Framework – TEF.



Source: Beni and Moesch (2017).

The TEF also has several intra- and inter-subsystem interactions, whose relationships and extensions feedback into interlinked systems in a knock-on effect. An event in the ecological subsystem can affect the social, economic, and market subsystems. For example, the Covid-19 pandemic, a biological factor of the ecological subsystem, spread across the whole world in early 2020

because of social mobility, a phenomenon of the social subsystem, smashing the economic subsystem and reverberating throughout all subsystems. New regulations imposed by countries (the superstructure subsystem) banned international visitors and established novel protocols for business. The tourism industry (the market subsystem) changed to adapt to the new safety procedures and run marketing campaigns to attract customers since destination infrastructure (including transport and healthcare access options) is often considered in advance by potential visitors before bookings. Nevertheless, every destination respond differently depending on the nature and timing of the destabilising event and the characteristics of the local system (tourist destinations, in this case).

Table 2.2 – Subsystems that interact within the TEF.

Subsystem			Description
Cultural			Cultural heritage interactions, local and regional customs, cultural norms, acculturation, local values, gastronomy, etc.
Ecological			It comprises the ecosystem services provided and the natural environment and tourism interactions - natural attractions, degradation/pollution, environmental education, conservation, visitor management, environmental heritage, carrying capacity, legal rules, climate change, and related issues.
Economic			It relates to employment and income generation, house market, tourist flow (national and international), exchange, inflation, GDP, production chain, multiplier effect, regional market, demand and suppliers, etc.
Social			Permanent and non-permanent population interactions, social norms, political and civil conflicts, wars, shifts in social relations due to technology, social mobility (locomote) and development type (endogenous vs. colonialist).
Market	Distribution	Production	Studies about tourist attractions, products, services, and venues available for tourists.
		Consumption	Components of marketing: demand analysis, customer decision making, psychological analysis, trends, tourism flow, etc.
Infrastructure			General: sanitation, transportation infrastructure (roads, railways, ports, airports), hospital, electricity, and communication. Specific: Restaurants, hotels, tour guides, and other services for tourists.
Superstructure			The regulatory system essential for tourism functioning: norms, rules, laws, public policies, among others, e.g., Visa policies and local transport rules.

Source: Beni (1997).

2.2.3 Tourist destinations as ‘living’ spaces and products

The complex processes of tourism production and consumption depend on a destination’s characteristics, be they a single self-contained entity (such as large resort complexes that are sold as a package), a community and its surroundings, a city, region, or country (SARANIEMI; KYLÄNEN, 2011). Considering that tourists perceive the destination as a unit that offers an integrated experience, it is of great importance to take a broad perspective when conceptualising tourist destinations, even though the experience or product is often produced and composed by individual actors (HAUGLAND et al., 2011). For example, The Maldives, a Small Island Developing State, can be seen as one single destination but continental countries such as United States, Australia, and Brazil (that are sometimes referred to in the popular media as destinations) offer a great diversity of tourism options (beach, nature-based, cultural, and so on) that characterize them as places of multiple tourist destinations.

However, while the term is commonly used in several contexts (e.g., marketing, management, planning, and sustainability), its definition is frequently neglected (PEARCE, 2014). Very few studies address definitional issues of the term and depict the complex and multifaceted characteristics of a tourist destination. The literature suggests five main approaches to define a tourist destination: (i) economic geography, (ii) marketing and management, (iii) the ‘smart’ destination concept, (iv) the sociocultural perspective, and (v) the system approach.

Arguably the most widely recognised, the economic geography view portrays destinations from a spatial perspective as the territorial limits where economic transactions occur (supply and demand) through a concentration (cluster) of tourist attractions, accommodations, transportation infrastructure to, from, and within the destination (accessibility and mobility), and other tourist-related services (FLORES; MENDES, 2014; HALL; PRAYAG; AMORE, 2017; JOVICIC, 2019; PEARCE, 2014; SARANIEMI; KYLÄNEN, 2011). The geographic component is very important and has been inherent in the

conceptualisation of a tourist destination to date. However, this static view of a fixed territorial unit where thousands or millions of tourists come and go via different routes – as depicted in Leiper's (1979) tourism system model – fails to capture the dynamic nature of destinations. Elements excluded are

- The cooperation within the destination (networks).
- The role of tourists and residents as actors in the tourism production.
- All related human experiences that shape territories over time.

Further, as Pearce (2014) notes, geographic spaces differ from places. Therefore, the spatial distribution of specialized tourism firms and activities (e.g., clusters) differs from attributes such as local contexts, e.g., sociocultural, and natural environment characteristics that cannot be geographically relocated or reproduced.

In a similar vein, the marketing and management perspective considers the destination from the viewpoint of the classical economic dichotomy: the role of producers (supply) and consumers (demand) in the production of tourism (SARANIEMI; KYLÄNEN, 2011). The major difference here is that the geographical, political, and administrative boundaries are considered to be less important than the geographical unit recognised (perceived) by visitors as the destination. Flores; Mendes (2014) suggest that these geographical, political, and administrative boundaries can be virtual or even inexistent. However, the destination must contain visitor attractions, an internal transport network, tourist infrastructure and superstructure, and be controlled by a management organisation (FLETCHER et al., 2018). Such control is often condensed into managerial checklists using marketing tools, for example the 4 Ps of product, price, place and promotion (KOTLER, 1997) that give rise to the destination marketing mix. The marketing and management approach plays an important role in tourism planning and destination management; however, this way of conceptualising a destination neglects the sociocultural aspects of both tourism consumption and production. Similar to the economic geography approach, this perspective also fails to acknowledge the complex dynamism of a destination.

Jovicic (2019) advocates a ‘smart’ approach to defining a tourist destination, which includes the interweaving of digital and physical realms, the public-private-consumer collaboration, participatory governance, personalized services, and the value of creative and knowledgeable people that co-create the destination. The ‘smart’ concept offers an important lens in this digital era of social media (virtual space), which shapes destination image, relativizing spatial limits (physical spaces). However, as with the other ways of defining destinations, this market-focus view that seeks to meet tourist needs excludes important components such as the sociocultural behaviour of tourists, communities, and residents that might reject artificial elements in the spaces and places visited. Another weakness of the smart perspective relates the fact that is still focused on elements of the traditional economic geography and marketing-management approaches, where the primary use of information and communication technologies is to maintain or enhance tourism flows, e.g., using tourists’ opinions from social media to shape destinations and offer the place they “want to visit”.

Saraniemi; Kylanen (2011) introduced an alternative approach, the sociocultural perspective, which represents destinations as spaces through which power, identity, meaning, and behaviour are constructed, negotiated, and renegotiated according to sociocultural dynamics. Such destinations are places where interconnected sets of institutions and actors, including visitors and local residents, produce and reproduce dynamic and complex practices. These practices, which include marketing-related transactions and activities, take place in a physical or a virtual space (ibid). Flores; Mendes (2014) share this view, noting that destination content is formed by attractions, culture, events, landscapes, and services, all of which are shaped by tourists in a dynamic and interactive process, and are adaptable to changes. Therefore, this view challenges the traditional production-consumption dichotomy and moves our understanding of the destination concept forward. By shedding light on the social and cultural relationships of a tourist destination Saraniemi; Kylanen (2011) acknowledge elements characteristic of a system: complexity, dynamism, and interaction of components.

The system approach frames tourist destinations as a complex adaptive system (CAS). Farrell; Twining-Ward (2004) Tourism Panarchy framework represents the CAS of tourism as a multi-level system that stretches from the core (portrayed as the tourism industry) to the global or Earth system, all of which levels are interrelated, open and hierarchical. These interactions, including related disturbances which are an inherent feature of an open system, shape the destination and build unpredictable connections and other components of the system. Baggio; Sainaghi (2011) consider a destination to be a nonlinear (complex) system that tends to chaos, and therefore to instability. Pearce (2014) also recognises the dynamic nature of destinations in his integrated conceptual framework. He stresses the non-permanent socio-spatial structure and the capacity of destinations to self-organise, innovate, and adapt under driving factors (e.g., climate change and Covid-19, although not mentioned in the original). This system approach allows for a more comprehensive conceptualization of destinations, providing a better analysis of the structural elements and their interactions. For example, the interdependence or complementarity of services and products such as accommodation and attractions, the companies' behaviour (cooperative or competitive) (PEARCE, 2014), and the other actors involved, including the residents and tourists' contribution to the production network, and their role as co-creators of the tourism system and 'product' (FLORES; MENDES, 2014)

Overall, the traditional economic geography, marketing-management, and smart destination perspectives portray destinations as a cluster of attractions (artificial or natural) and services located in a given geographic space where the production-consumption relation occurs. However, these perspectives fail to acknowledge linkages between stakeholders within the destination, and generally fail to recognise both tourists and residents as actors that shape destinations - the smart concept considers tourists but neglects the resident component. The sociocultural perspective and the system approach, however, embrace the interactions between stakeholders: tourists, companies (service providers), and residents of destinations, all of which are in constant contact with macro elements and forces (externalities such as climate change, global

economic volatility, and pandemics). These perspectives recognise clear feedback loops due to their non-linear connections between stakeholders and take into consideration the public-private cooperation networks that integrate and manage resources to produce successful experiences in tourism.

The TEF encapsulates the five approaches to conceptualising a tourist destination. The spatial perspective taken by those adhering to the economic geography approach refers to a “tourism space”, where actors and subsystems interact. When comparing this approach with the TEF we can see that supply and demand transactions are included in the market subsystem; tourist attractions are included in the cultural, natural, and social subsystems and accommodation, transportation systems and access, and tourism-related services, are all captured by the infrastructure subsystem. The marketing and management perspective is also covered in the TEF and is depicted in both the market subsystem and in the (local/regional) governance of the tourism space, considered in the superstructure subsystem. The smart destination dimension, which focuses on communication and technological issues, is mostly represented in the social subsystem. Finally, the sociocultural perspective, along with the idea of the systems approach are both clearly identified in the operationalisation of the TEF: complex and dynamic practices that take place in ‘spaces’ where social interactions (between visitors, local residents, social and organizational actors), shaped by power, identity, and meaning, produce and reproduce the ‘place’, - the destination system.

Drawing insights from previous work on conceptualising destinations that depict a wider range of factors and relationships, from the TEF, and from GST which states that organisms result from the sum of all their parts and the interactions and properties that emerges from these connections, this research postulates that the tourist destination emerges from the interactions and network connections within the tourism system. Thus, a tourist destination can be understood as a dynamic and ‘living’ place that emerges from the tourism ecosystem interactions that take place in a geographical area whose limits are defined by the stakeholders (tourism industry, government, visitors, social and

organizational actors, and residents) who shape the governance system and the sociocultural dynamics of power, identity, and meaning. Such interactions between stakeholders and with externalities (e.g., climate, Covid-19) co-create a virtual and physical world in the visitor's mind, which is determined by periodical factors (cultural festivals or seasons) that influence the 'destination product', consequently, the tourism experience. These bullet points may clarify this definition and underpin its usefulness to stakeholders:

- A destination comprises a set of actors or stakeholders (residents, tourism industry, government, tourists, and institutions – non-government agents) that are dynamically interconnected in a physical and/or a virtual space.
- A destination has geographical limits which are relative and dynamic and are defined by: (1) visitors, who decide what to do/see in the destination; (2) tourism production networks (food, accommodation, attractions, transportation, etc.); and (3) the governance system that embraces institutions, actors, and sociocultural dynamics.
- A destination is not just a space, but rather a place portrayed and created by sociocultural dynamics, shaped by power, identity, meaning, and actors' behaviour.
- A destination is co-created in the physical and/or virtual space through public-private/tourist-resident interactions, governance, creativity processes, and personalized services.
- A destination will vary in how it is perceived, and how attractive it is according to local contexts such as cultural festivals and seasons of the year (periodical factors).

The practical application of this rather complex definition may be somewhat challenging. However, rather than being a barrier to research, this complexity serves to reinforce the importance of clear articulation of the definition of a 'tourist destination' that authors are using when reporting the results of a study. More studies should investigate, discuss, and apply the concept to different tourism regions over the world to verify its practical and empirical usefulness for a better understanding of what a tourist destination is.

3 DEVELOPING A COASTAL TOURIST DESTINATION TOOL TO ASSESS VULNERABILITY AND RESILIENCE TO CLIMATE CHANGE: THE COASTOURD INDEX

3.1 Introduction

Tourist destinations are usually planned and managed with insufficient information, and the indicators that composite an index are an early warning tool for destinations' managers about potential risks posed by the climate crisis and a signal for possible action (UNWTO, 2004). Indices are used in a wide range of policy and business decision-making contexts, including tourism e.g., Travel and Tourism Competitiveness Index, Tourism Climate Index, Destination Brand Index (HINKEL, 2011; SCOTT; HALL; GÖSSLING, 2019). They play a key role in operationalizing VUL/RES as they can yield critical information, support systematic comparison across different destinations, and enable progress to be tracked in a way that is simple and accessible to decision makers (BRIGUGLIO et al., 2008; HINKEL, 2011; SCOTT; HALL; GÖSSLING, 2019; VINCENT, 2004). Therefore, the study in section 3 focuses on the development of the Coastourd Index, an analytical and valuable tool to better comprehend, identify and measure the factors that lead VUL/RES at the destination level under a global changing climate.

3.2 Understanding the theoretical basis of vulnerability and resilience of tourist destinations to climate change

3.2.1 Vulnerability and resilience: intertwined concepts applied to tourism

VUL/RES are intertwined yet distinct concepts. They are considered a complex property of the complex social and ecological systems, commonly referred to as coupled human-environment systems or social-ecological systems (SESs) that is place- and system-specific, contextualised, highly scaled, dynamic, and differential (ADGER, 2006; CALGARO; LLOYD; DOMINEY-HOWES, 2014; TURNER et al., 2003). VUL/RES are influenced by a combination of multiple, dynamic, and interacting factors including unequal access and entitlement to

resources (socio-political, economic, physical), social norms and structures, governance processes, and geographical exposure (ADGER, 2006; BIRKMANN et al., 2013; WISNER et al., 2005). Factors that regulate an individual's or group's ability to access socio-political, economic and environmental resources in a given place and time include power systems, formal and informal governance structures and processes, social norms, culture and human agency (ADGER, 2006; BIRKMANN et al., 2013).

Vulnerability encompasses the biophysical vulnerability, social vulnerability, risk to harm, and adaptation. It is defined as the susceptibility of a system to disturbances (either a single specified hazard or an often-compounding range of shocks and stressors) and is determined by exposure and sensitivity levels to these perturbations, and the capacity to adapt (ADGER, 2006; BROOKS, 2003; IPCC, 2014; NELSON; ADGER; BROWN, 2007). This research uses the concept of vulnerability in the tourism context as the propensity or predisposition of tourist destinations to be adversely affected due to their exposure, sensitivity, or susceptibility to harm, followed by their lack of capacity to cope with and adapt to disturbances (shocks and/or stressors).

The three core dimensions of vulnerability (exposure, sensitivity, and adaptation) are routinely used to make sense of the complexity of vulnerability in vulnerability assessments, including those focussed on CC (IPCC, 2014). Exposure of a tourism SES relates to the presence of attractions, livelihoods, business, species, or ecosystems important for tourism, people and their services and resources, infrastructure, economic, social, or cultural assets in places and settings that could be adversely affected by climate variations (IPCC, 2014). Sensitivity refers to the degree to which a tourism SES can be affected by, or responsive to a climate event (e.g., a storm or a hurricane). System Adaptiveness is understood as the dynamic state of the tourism SES to effectively respond to multiple stresses and/or shocks, including immediate cope responses and anticipatory set of actions (preparedness), to maintain its main functions and structural identity in the short and longer-term, incorporating adjustments and adaptations that moderate or avoid harm or even exploit

beneficial opportunities (CALGARO; LLOYD; DOMINEY-HOWES, 2014; IPCC, 2014; NELSON; ADGER; BROWN, 2007).

The concept of ‘resilience’ has been applied to multiple contexts. According to Privotolo; Reghezza-Zitt (2015) the term “resilience” was first used in 1901 for the first time in a scientific context to measure the resistance of a material. In the 1940s, the term was used in the discipline of psychology to refer to an individual’s or groups’ ability to manage and overcome the destructive consequences of traumatizing situations (PROVITOLO; REGHEZZA-ZITT, 2015). In the early 1970s, Hollling (1973) developed and applied resilience theory in ecological sciences in order to describe ecosystem processes. Resilience theory was later applied to the complex SESs (ADGER, 2000; FOLKE, 2006; LEVIN et al., 1998). Resilience theory accepts that nature is inherently unpredictable and that systems are complex and dynamic (BERKES; COLDING; FOLKE, 2001).

The term has now been used in a wide variety of living systems research to understand interactions between nature and humans (CARPENTER et al., 2001), giving rise to several resilience research strands found in different fields of science. Table 3.1 presents these strands that relate specifically to the context of SESs. Despite differences in their emphasis, each resilience strand includes common properties, namely: 1) a shock, stressor, or disturbance that threatens or destabilises the system; 2) the idea of a continuum; and 3) a shift in the system’s interactions to maintain this “continuum”. Understanding these central properties is critical when exploring complex adaptive systems like tourism SES’s.

Resilience theory has been embedded in many studies among tourism researchers to better understand the complex interactions that determine VUL/RES levels and society’s ability to cope with crises, systemic shocks and change (BECKEN, 2013; BIGGS; HALL; STOECKL, 2012; FARRELL; TWINING-WARD, 2004; LOEHR, 2020; MORENO; BECKEN, 2009; STUDENT; LAMERS; AMELUNG, 2020). This includes the complex and unpredictable interrelations between tourism and climate, in which ecosystems, individuals,

Table 3.1 – Resilience strands and their focal points.

Strands	Emphasis & focal point	Reference
Ecological resilience	The magnitude, the amount of disturbance that can be absorbed before the system changes its structure and behaviour.	Holling et al. (1995)
Social resilience	The capacity of individuals and social groups (including their institutions) to adapt to and to cope with environmental changes. This strand focuses on the social sphere but acknowledges interactions with the ecological system on which social systems depend.	Adger (2000)
Community resilience	Safeguards the physical integrity, ensuring the continuity of economic, administrative, and business activities. Ensuring that the community members have the resources, capacities, and capabilities necessary to utilize the physical and economic resources to minimize disruptions.	Paton; Johnston (2001)
SES (holistic) resilience	The capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks.	Adger et al. (2005); Walker et al. (2004)
	The capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation.	IPCC (2014)
	The ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform, and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management.	UNDRR (2017)
Economic resilience	The inherent and adaptive responses to disasters that enable individuals and communities to avoid potential losses.	Rose, 2004
	Refers to the policy-induced ability of an economy to recover from or adjust to the negative impacts of adverse exogenous shocks and to benefit from positive shocks.	Briguglio et al. (2008)
	The economy's ability to recover from, or adjust to, the effects of adverse shocks to which it may be inherently exposed.	Bec; Moyle; Moyle (2019)
Tourism enterprise resilience	Ability to maintain its existing level of employment and income and stay operating in reef tourism in the face of a large disturbance or disturbances.	Biggs (2011)
Regional resilience	The ability of a region to prevent, prepare for, respond to and recover after disturbances, so that such disturbances are not obstacles to the region's development. […] the capacity of a regional economy to i) withstand external pressures, ii) respond positively to external changes and iii) adjust and learn.	Karoulia; Gaki; Kostopoulou (2015)

organisations, and society may respond to disturbances and changes in both subsystems (BIGGS et al., 2015). For this research, tourism resilience is the ability of destinations to cope with and adapt to disturbances (shocks, stressors, or threatens) in order to maintain their attractiveness and visitation rates close to their normal patterns, regardless their need for a radical transformation (e.g., from a beach to a cultural destination).

Resilience of an SES is often seen as the antonym of vulnerability, posing respectively a positive and negative meaning to the concepts (ADGER, 2000; BIGGS et al., 2015; NELSON; ADGER; BROWN, 2007). However, Walker et al. (2006) rightly refutes this based on the following observations. If adaptability is accepted as a property that increases resilience, then from an opposite perspective strong adaptability is supposed to decrease vulnerability (ibid.). Conversely, it can lead to a loss of resilience because adaptability to a known impact can generate increased vulnerability to unknown or extreme impacts (ibid.). Other literature defines resilience as being a component or subset of vulnerability (see BIRKMANN, 2013; GALLOPÍN, 2006). However, the relationship between VUL/RES cannot be reduced to either strict opposition or even inclusion: there is a continuum between the two of them, meaning that, from a wider perspective, vulnerability can be intertwined with and modified by resilience (PROVITOLO; REGHEZZA-ZITT, 2015). VUL/RES are co-constituted properties of and coexist in the same SES, comprising households, communities, institutions, natural environment, and economies, which are under a constant dynamic flux (CALGARO; LLOYD; DOMINEY-HOWES, 2014). Accepting this, I recognise both the tourist destination constraints (vulnerabilities) and opportunities (resiliencies) as intertwined system properties and use this understanding to inform the Coastourd Index.

3.2.2 Vulnerability and resilience assessment frameworks for tourism

Multiple vulnerability frameworks and assessment tools have been developed since the late 1990s, most of which focus on disaster risk reduction and CC (BIRKMANN, 2013). However, this research focuses on critique tools and key frameworks that have been applied to the tourism context and rate their

usefulness against the key drivers of VUL/RES. Using a set of criteria, Table 3.2 highlights the gaps in eleven systems frameworks that try to capture and explain the factors, processes and interactions that influence patterns of destination VUL/RES. The key strengths and weaknesses of these frameworks are discussed below.

The work of Farrell; Twining-Ward (2004) signals a distinctive shift from the analysis of select SES elements to a more holistic examination of the tourism system. Out of 150 models identified in the literature, Farrell; Twining-Ward (2004) found that only four attempted to take a whole systems approach. Drawing heavily upon ecological understandings of resilience theory, they fill this gap by presenting their Tourism Panarchy model that portrays the tourism system as a multi-level system stretching from the core (the tourism industry) to the global or Earth system, all of which are interrelated, open and hierarchical (ibid.). Their contribution clearly showed the tourism system to be as a complex adaptive system that is firmed embedded in a wider supporting SES. Other researchers have followed suit; Moreno; Becken (2009), Becken (2013), Calgaro; Lloyd; Dominey-Howes (2014), Loehr (2020); and Student; Lamers; Amelung (2020) have applied holistic systems thinking to better understand the drivers and dynamism of VUL/RES to destabilising risks (including climate change impacts) in tourist destinations, the wider tourism system and the SES that supports tourism activity.

Moreno; Becken (2009) proposes a Vulnerability Scope Diagram (VSD) in order to identify key components (exposure, sensitivity and adaptation) that determine coastal destination's vulnerability to climate change by outlining a five-step assessment that includes: (i) a system analysis; (ii) the identification of activity and hazard subsystems; (iii) an individual vulnerability assessment for each subsystem at risk: (iv) integration of the individual assessments, and (v) communication of results. Their approach incorporates the essential factors that cause exposure and influence sensitivity and, importantly, offered a qualitative and quantitative evaluation of each subsystem at risk. However, VSD does not depict all aspects of the tourism system. As highlighted in Table 3.2, they do not

consider factors that increase exposure levels to shocks or stressors. They also fail to acknowledge the interlinkages and feedback mechanisms between the different subsystems and overlook the powerful role of contextual characteristics (power systems, cultural norms, human agency, etc.) that play in determining differential VUL/RES patterns within the SES and its subsystems.

Although there is a strong interest in understanding the multiple drivers of VUL/RES in tourism systems, much research (and their purpose-specific frameworks) focuses on select components of the tourism system, most notably those related to economics. Scott, Gossling; Hall (2012) analyse the vulnerability of international tourism to CC. They focus on the impacts that future climate projections will have on international demand and flow (market subsystem) and include a few elements of the social, superstructure, and economic TEF subsystems. However, their focus on international issues does not help to understand interactions at a local and regional scales that directly affect destinations' VUL/RES (i.e., power systems, governance, cultural norms, political access to resources – see Table 3.2), and the other TEF subsystems.

Biggs, Hall; Stoeckl (2012) assessed the resilience of tourism businesses in Thailand to the 2004 Tsunami and the 2008 financial/political crisis. Using a qualitative methodology, they examined five elements from the economic and social tourism subsystems: enterprise experience; social capital; human capital; financial conditions; and reported lifestyle benefits. Dogru et al. (2016; 2019) applied a similar approach but using quantitative research to evaluate the economic VUL/RES of tourism to climate change. Taking a macro perspective, they identified correlations between climate/non-climatic factors, the countries' tourism receipts, and their Gross Domestic Product (GDP) to compare the resilience of 90 countries. While both studies achieve their purpose of identifying important economic drivers of destination VUL/RES (e.g., system diversity and political economy of access that influence sensitivity) they overlook the wider tourism system, including place-based specificities that are affected under extreme climate and are integrated to the wider supporting system. These include natural terrain features, destination's history, and tourism seasonality. Their approach also lacks a qualitative-quantitative analysis.

Table 3.2 – Gap analysis of tourism system frameworks for assessing destination's vulnerability and resilience.

Framework / Attributes of vulnerability & resilience		Tourism Panarchy Model	Vulnerability Scoping Diagram	CC Impact Pathways on International Tourism	Resilience of Tourism Enterprises to Disasters	Analytical Framework of a Stability Landscape	Destination Sustainability Framework	Comprehensive contextual CC vulnerability framework	Tourism Industry Vulnerability to CC	Vulnerability Assessment Framework	Destination Climate Risk Framework	Dynamic Vulnerability Approach
Research domain		Resilience/ Ecology	Vulnerability/ Sustainability Science	CC modelling / Business	Business/ Organizational Resilience	Resilience	Sustainability Science	Vulnerability/ Sustainability Science	Vulnerability / Climate Science	Vulnerability/ Sustainability Science	Climate Risk/ Adaptation	Vulnerability/ Modelling
Select research examples of application to tourism system issues		Farrell; Twining-Ward (2004)	Moreno; Becken (2009)	Scott; Gossling; Hall (2012)	Biggs; Hall; Stoeckl (2012)	Becken (2013)	Calgaro; Lloyd; Dominey-Howes, 2014)	Hopkins (2015)	Dogru; Bulutt; Sirakaya-Turk (2016)	Jamaliah: Powell (2019)	Loehr (2020)	Student; Lamers; Amelung (2020)
Focus		Tourism as a multi-level adaptive system	Factors driving VUL of tourism activities to CC	CC driving tourism demand and flow	Climate factors driving resilience of tourism business	Tourism activities subsystems	Whole system dynamics driving VUL/RES in destinations	Factors driving VUL of tourism industry to CC	Economic factors	Ecotourism system	System adaptation dynamics driving climate risk in destinations	Whole system dynamics driving VUL in destinations
Identifies vulnerability as a product of:	Human system	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Biophysical system	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Vulnerability/resilience are place and/or system-specific		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Vulnerability/resilience are highly scaled		✓	✓	✗	✗	✓	✓	✓	✗	✗	✓	✓
Recognition of the dynamism of systems and their vulnerability/resilience - characteristics of shocks, systems, and social groupings constantly change		✓	✗	✓	✗	✓	✓	✓	✗	✗	✓	✓
Inclusion of multiple shocks and stressors		✓	✗	✓	✗	✓	✓	✗	✓	✓	✗	✓
Listing of exposure causal factors (including physical positioning of development) to shocks or stressors		✗	✓	✗	✗	✗	✓	✗	✓	✗	✓	✗
Inclusion of factors that influence a system's sensitivity		✓	✓	✗	✓	✓	✓	✓	✓	✗	✓	✓
Inclusion of tourism-specific sensitivities i.e., main markets & marketing strategies, seasonality, destination development histories, and image sensitivity to risk perceptions		✗	✗	✓	✗	✓	✓	✗	✗	✗	✓	✗
Includes the way in which systems experience shocks and surprises and their capacity to respond, adjust and adapt		✓	✓	✓	✓	✓	✓	✓	✗	✗	✓	✓
Inclusion of political economy of access and entitlements to resources (including governance & institutional flexibility)		✗	✗	✗	✓	✓	✓	✓	✓	✗	✓	✗
Vulnerability/resilience are contextual and influenced by power systems, cultural norms, ideologies, human agency, attitudes, perceptions, expectations and experiences		✗	✓	✗	✓	✓	✓	✗	✗	✗	✓	✓
Portrayal of the causal sequence of vulnerability/resilience (including feedback mechanisms) over space and time		✓	✗	✗	✗	✗	✓	✗	✗	✗	✓	✓
Analyses tourism system from a qualitative and quantitative approach		✗	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗
Inclusion of all subsystems of Sistur		✗	✗	✗	✗	✓	✓	✗	✗	✗	✓	✗
Defines and establishes destinations' boundaries		✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗

Source: Adapted from Calgaro; Lloyd; Dominey-Howes (2014).

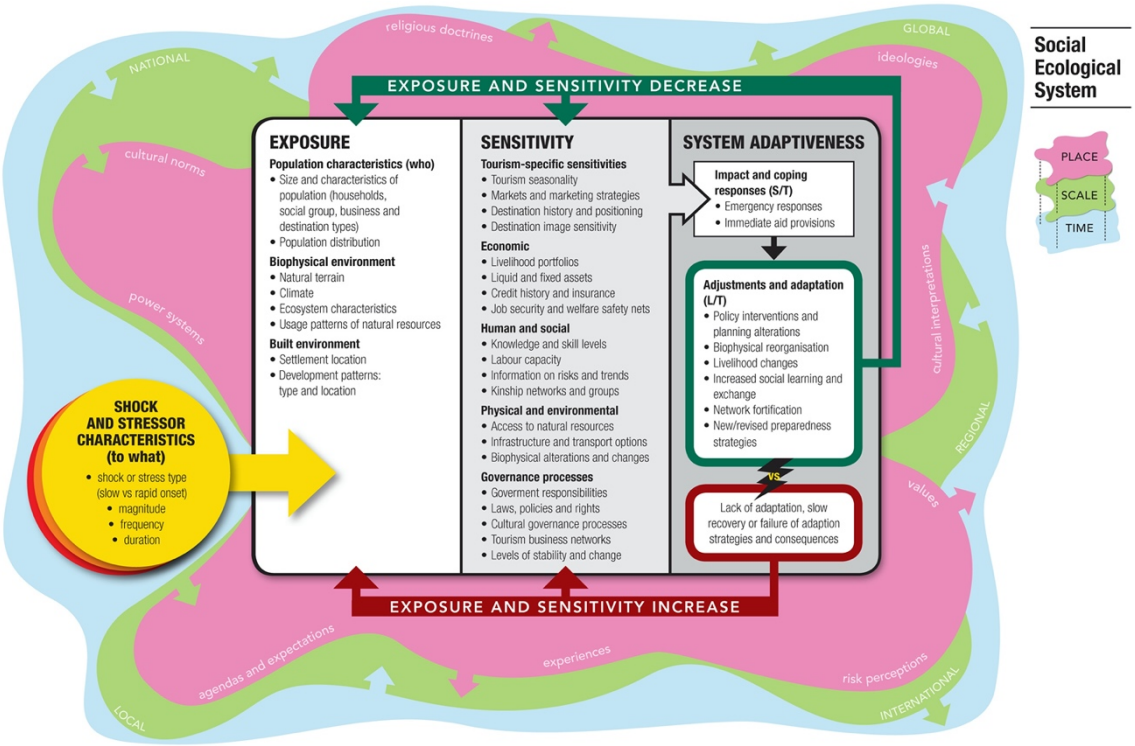
Becken's (2013) Analytical Framework of Stability Landscape (AFSL) analyses the resilience of tourism activities. In operationalizing the framework, she presents three concepts embedded in resilience thinking: 1) Resistance, seen as the disturbance factors (e.g., weather and climate thresholds); 2) Latitude, related to operation or management factors that drive the system (e.g., market diversity); and 3) Precariousness, that focuses on how close the system is to thresholds (e.g., disruption of ski activities due to climate conditions). The AFSL identifies important details that drives resilience at the lower level (the core) of the Tourism Panarchy model (FARRELL; TWINING-WARD, 2004), which is the tourism industry. However, Becken (2013) acknowledges that it fails to capture all factors from the wider tourism system and proposes the undertaking of general resilience assessment that considers many of the attributes highlighted in Table 3.2, except for quali- quantitative approaches, exposure causal factors and the inherent feedbacks over space and time.

Calgaro; Lloyd; Dominey-Howes (2014) present the Destination Sustainability Framework (DSF) for analysing destination vulnerability and resilience to multiple shocks and stressors (Figure 3.1). Adopting an inclusive SES approach, the authors combined a range of contemporary perspectives from disaster risk reduction, resilience-thinking, sustainability science and geography (most notably, theories of relational scale, place, and time). The starting point on analysis in the DSF is the identification of what people are vulnerable to – depicted as the trigger shock or stressor that destabilises the system – and determining the pre-existing physical attributes (listed under exposure) and social characteristics (grouped under sensitivity) of the system that influence its ability to withstand the impacts of the shock. It also charts how resources (listed under the sub-categories of economic, human and social, physical and environmental) are used to respond and cope post-event (depicted by the arrow linking the resources listed under sensitivity to system adaptiveness), and the outcomes of response actions on future vulnerability levels (depicted via the feedback arrows).

Hopkins (2015) and Jamaliah; Powell (2019) present important factors that contribute to VUL/RES of destinations to CC, but their scope is limited to

particular components of the tourism SES. Hopkins (2015) presents a comprehensive contextual climate change vulnerability framework to qualitatively assess the vulnerability of New Zealand's tourism industry (national scale) and included a range of non-climatic factors (e.g., human and biophysical systems), interactions, and feedbacks that stretched beyond tourism system. However, local factors like power and cultural norms as well as tourism-specificities are overlooked. Jamaliah; Powell (2019) qualitatively assessed the vulnerability of the tourism system to climate change in a Jordanian Biosphere Reserve, concentrating on social, environmental, and economic components (the three main core issues of sustainability). Restricting the focus of analysis to specific components of the SES, however, ignores the full dynamism of the tourism system and that of the destination subsystem, which often leads to incomplete understandings and inappropriate resilience-building solutions (see BEC; MOYLE; MOYLE, 2019; CALGARO; LLOYD; DOMINEY-HOWES, 2014).

Figure 3.1 – The Destination Sustainability Framework.



Source: Calgaro; Lloyd; Dominie-Howes (2014).

Using concepts embedded in the DSF, Student; Lamers; Amelung (2020) have proposed a Dynamic Vulnerability Approach (DVA) to qualitatively evaluate the

vulnerability of tourist destinations to climate change and use this dynamic tool to identify critical challenges for coastal tourism in the Caribbean islands of Barbados and Curacao. Inspired by Calgaro; Lloyd; Dominey-Howes (2014), their human-agent-based framework encapsulates five principles: human agency, heterogeneity, feedbacks, uncertainty, and iteration. Employing a stakeholder-focussed analysis, the DVA succeeds in capturing the dynamics that occur within the destination and provides an agent-based modelling that take future scenarios and multiple uncertainties into account. This is a valuable tool for helping policymakers understand destination VUL/RES dynamics and taking appropriate action. However, its reliance on questions that focus exclusively on local processes garnered from destination-based tourism industry might miss broader VUL/RES drivers that operate outside the destination (e.g., destinations' image) and in different sectors and scales (e.g., national and subnational policies) portraited respectively in tourism-specificities and governance processes of Table 3.2. The DVA also excludes the factors that influence exposure levels.

Loehr (2020) has developed a Destination Climate Risk Framework (DCRF) to assess the Tourism Adaptive System of the Pacific Vanuatu Island. The framework comprises of eight categories that explain almost all the factors listed in Table 3.2: (1) the Risk Framework (summarises risk dimensions); (2) the Tourism & Development, (3) Community & Culture and the (4) Natural Environment, all of three summarise SES elements; (5) Governance, (6) Finance, (7) Information & Education, and (8) Human Psychology are socio-economic and political variables that influence the system capacity to address climate risk. The major contribution of Loehr's (2020) work is the identification of key system variables that either directly or indirectly influence system outcomes to reduce climate risk, the processes that link them, and showing how drivers are interlinked to other variables and outputs. However, the main weakness regards to its inability to map the shocks and stressors to which the system (the destination) is at risk as well does not combine qualitative and quantitative approach.

While the five system approach frameworks are impressive, each falls short in providing all the elements needed to undertake a comprehensive quantitative analysis of the dynamic and highly-scaled tourism system and it's supporting SES. This is, in part, due to differences in their designed purpose highlighted in Table 3.2. Moreno and Becken (2009) do provide a quantitative and qualitative approach but overlook system feedbacks. Becken (2013) proposes a valuable seminal framework to operationalize resilience theory in the tourism industry context but fail to develop a methodology that includes the overall system at the destination level. Calgaro; Lloyd; Dominey-Howes (2014), Loehr (2020), and Student; Lamers; Amelung (2020) consider several attributes of vulnerability and resilience such as feedbacks into the entire SES. However, their frameworks are anchored in qualitative approaches. A robust quantitative perspective is missing. Quantifying the key factors that influence VUL/RES in tourism contexts – including feedbacks involved – provides decision-makers' with critical information needed to justify and take actions aimed at reducing vulnerability levels and increasing resilience to future risks.

Of all the frameworks critiqued, the DSF is the most comprehensive in identifying the factors and processes that determine differential levels of VUL/RES in a given space and time and, in turn, the most useful in guiding the creation of the Coastourd Index. Of particular note is the inclusion of all TEF subsystems (shown in Table 3.2), mainly the tourism one. DSF acknowledges tourism sensitivities (seasonality, markets and marketing strategies, destination image sensitivity levels), and destination-specific development characteristics (destination history and positioning) that influence vulnerability and resilience levels in the tourism context (CALGARO; LLOYD; DOMINEY-HOWES, 2014; LAMBERT et al., 2010; TURTON et al., 2010). Finally, the DSF recognises the dynamism of vulnerability and resilience and the deep-rooted contextual factors (shown in place) that shape all social actions and processes (including vulnerability's creation and perpetuation) across multiple scales of social organisation over time. Moreover, DSF has been tested and applied in other tourism assessment studies, most notably vulnerability case studies by Jiang et al. (2015), Van Der Veeken et al. (2016) , and Pyke et al. (2018). It also has

been used as a reference framework for new models' conception in disaster context (AK. MATUSIN; SIWAR; ABDUL HALIM, 2019), conflict and political instability context (REDDY; BOYD; NICA, 2020), and tourism in the context of climate change (Student, Lamers & Amelung, 2020). Its primary weakness is its inability to quantitatively measure the qualitative drivers of VUL/RES.

3.2.3 Climate-related indices in the tourism context

In the context of CC, VUL/RES assessments of tourist destinations aim to understand at-risk resources (weaknesses) as well as the strengths embedded in the destination and supporting SES to develop strategies to effectively respond to climate change impacts, enhancing resilience while reduce vulnerability (DOGRU et al., 2019). Qualitative research provides the theoretical pillars that are essential for comprehending dynamic interactions within the system, how components respond to external and internal factors, and the extent to which these components are interrelated. Equally important are quantitative assessments of these same factors that decision makers need to justify resilience building actions, guide policies and funding decisions at the destination level. Indices are useful quantitative mechanisms for: reducing, simplifying, communicating, and summarizing a large amount of complex information in a format that is simple and understandable. They also provide benchmarks for assessing performance and progress over time, raise awareness of persistent issues, and aid in prioritizing actions (COX; HAMLEN, 2015; CUTTER; BURTON; EMRICH, 2010; HINKEL, 2011; PERCH-NIELSEN, 2010; SCOTT; HALL; GÖSSLING, 2019).

Several researchers have endeavoured to create indices to measure VUL/RES but the great majority focuses on rating risk levels of communities to climate-associated disasters. Very few studies developed indices in the context of tourism and CC. Mieczkowski (1985) proposed the first one – The Tourism Climatic Index (TCI) – to evaluate climatic comfort for tourists based on five meteorological parameters: air temperature, relative humidity, precipitation, wind speed, and hours of sunshine. The TCI innovatively link tourism and climatic comfort and many researchers have used it to estimate the favourability

of climate and climate changes on tourism activities (AMELUNG; NICHOLLS, 2014; AMELUNG; NICHOLLS; VINER, 2007; OLYA; ALIPOUR, 2015; ROSSELLÓ-NADAL, 2014; RUTTY; SCOTT, 2015). However, climate comfort is only one of the several elements that affect tourists in the destination (see section 3.3.2.1).

A second index proposed by Perch-Nielsen (2010) assessed and compared the vulnerability of beach tourism to CC in 51 countries using quantitative data. This innovative study developed a robust and transparent methodology, and its framework was the first quantitative one to recognize that the vulnerability of tourism was determined by differential levels of exposure, sensitivity, and adaptation. Its primary limitation is its focus on beach tourism at a country level, which precludes insights into the full scope of CC and the tourism SES across the entire destination. The number of indicators related to tourism was also limited (13), disregarding many components of Sistur and other factors that influence VUL/RES, i.e., seasonality, destination image, and marketing strategies.

Guided by the CC Impact Pathways on International Tourism Framework (SCOTT; GÖSSLING; HALL, 2012,, featured in Table 3.2), Scott; Hall; Gossling (2019) developed a third index (and the last one found in the scientific literature) – the Climate Change Vulnerability Index for Tourism (CVIT) – to evaluate the vulnerability of tourism to CC in 181 countries. Their approach captures several important drivers of VUL/RES such as tourism demand and markets as well as the quality of transport infrastructure and governance. However, it does have five weaknesses. First, the index is heavily skewed toward economic indicators, with 10 of the 27 indicators focusing on economic issues and international tourism flow. This overlooks other key influencing factors, including natural terrain, cultural processes, settlement location, and population characteristics. Second, the CVIT's focus on the national and international scale neglects domestic and local issues that influence destinations' VUL/RES. For example, international visitors' absence due to border closures in China during the COVID-19 pandemic was compensated by

a strong domestic tourism flow that reached 60%-80% of hotel occupancy rates by August 2020 (data from YEPING, 2020).

Third, 15 of the 27 indicators to composite CVIT are indices (index made of indices), adding multiple layers of uncertainty and making difficult for stakeholders to identify the determinants of VUL/RES and therefore fails to capture the complexity of the real world. Fourth, four indicators consider projections of change for three different tourism segments, assuming that all countries possess natural assets for ecotourism, ski and beach tourism, which is not the case. For example, measuring percentage of the land area below 4m above sea level does not affect “beach tourism” of about one quarter of the landlocked countries in the world. The same analysis applies for ski tourism indicator. Finally, another two indicators taken from Hamilton; Maddison; Tol (2005) are outdated and are composited of only three factors that determine international flow (departures and arrivals): climate change, population growth, and income *per capta*, all of which cannot explain international flow by themselves. Considering these gaps, here it is presented a novel, contextual, and holistic index to measure VUL/RES in the context of tourism and CC.

3.3 The coastal tourist destination index to assess vulnerability and resilience to climate change – Coastourd index

3.3.1 The methodological process for constructing Coastourd

Drawing insights from the literature (notably, CUTTER; BURTON; EMRICH, 2010; HINKEL, 2011; KUSUMASTUTI et al., 2014; OECD, 2008; PERCH-NIELSEN, 2010; VINCENT, 2004), I undertook the following three technical steps to create Coastourd Index, which are detailed in the next subsections:

1. Development or adoption of a conceptual framework (DSF) that defines the system’s boundaries and provides the parameters for guiding indicator’s selection.
2. Selection of indicators, including criteria, data related treatment such as missing values, and data source.

3. Normalisation with transformation of values, sensitivity analysis to test robustness of the indicators, scoring, weighting and aggregation of indicators.

3.3.1.1 The conceptual framework and guiding parameters

Making theoretical concepts operational starts with the provision of a method (framework) for identifying observable concepts and parameters (HINKEL, 2011; OECD, 2008). Based on the gap analysis of tourism system frameworks undertaken in section 3.2.2, I chose DSF as the guiding framework for building the Coastourd Index because it includes most of the key attributes and drivers of VUL/RES in the tourist destination and SESs. These conceptual attributes have been included in the Coastourd Index as indicators for measuring and quantifying differential levels of VUL/RES to climate change in tourist destinations and the supporting SES. Indicators constitute one approach for making VUL/RES operational and quantifiable. They are measurable variables (quantitative) observed in the real world to explain theoretical variables (qualitative), where the observable variable (O) only becomes and indicator if associated to a theoretical variable (T) by means of a function: $O \rightarrow T$ (HINKEL, 2011). Indicators are the elements that composite an index and they encapsulate the complex reality in single construct (HINKEL, 2011; VINCENT, 2004).

3.3.1.2 Selection and refinement of indicators and data source

A crucial step in the creation of an index is the identification of indicators that are relevant, robust, and representative, characteristics that determine the relevance of the index (BORUFF; EMRICH; CUTTER, 2005). The 55 selected indicators described in Table 3.4 mirror the nine broad dimensions or subindices listed in DSF (Figure 3.1). The OECD (2008) and Hinkel (2011) guide the selection criteria for indicators, which should be: relevant to the subindex; quantified at the local scale with application worldwide; accurate; consistent with current knowledge; broad spatial relevant; and should depict the reality at a local context. In addition, indicators must identify emerging issues

such as impacts (allowing prevention) and be measurable for constant monitoring so that lead to continuous improvement.

To provide a complete dataset, the missing values are excluded from the calculation. And to deal with data gaps and to consider the local contexts of each destination where Coastourd might be applied, this study provides a full list of indicators that can guide users to conduct assessment of coastal destinations worldwide. Similar approach has been adopted by Basurto; Gelcich; Ostrom (2013) in which they listed 42 factors to identify governance processes that lead to a successful self-organization of a SES. It is unlikely that destinations can keep tracking of all variables listed in Table 3.4 and it might have others, but these are the main ones I identify as key indicators based on literature, consultation with experts, authors' expertise, and from ground information where indicators were applied, supporting the inclusion/exclusion of indicators in the final list.

Data sources constitute a very important issue in the composite of indicators since they compromise results reliance. Therefore, secondary data are gathered from official organisms or from published literature. Questionnaires and interviews provide primary data. To capture the multiscale levels framed in DSF, the list of stakeholders that provides with both primary and secondary data includes governmental institutions from local and regional level (e.g., local and regional tourism organism) as well as national/regional/local organizations (e.g., NGOs, tour operators) all of which play different roles in the local decision-making process and can impact in the VUL/RES of the tourist destination.

3.3.1.3 Normalization, scoring, robustness test, aggregation, and weighting of indicators to quantify subindices

The score values for all indicators in Coastourd Index are between zero and one, where the desired condition is zero, whilst 1.00 expresses maximum vulnerability and minimum resilience. The final score for each subindex is categorised in five levels: very low (0 to 0.2), low (0.201 to 0.4); medium (0.401 to 0.6); high (0.601 to 0.8); and very high (0.801 to 1). Several techniques are

used for scoring indicators. Indicators that use primary and secondary data is performed as following:

1. Indicators that ideally have the value of 100 percent (e.g., percentage of workers relying on tourism-related field) are scored as they are.
2. Qualitative indicators from primary data are measured using a Likert scale, where the averaged result is transformed into a 0-1 scale. For example, to measure 'trustworthiness' stakeholders answer questions in a 5-point scale (1 = strongly agree, 5 = strongly disagree) and the average of responses is normalised between 0-1. Such a method is commonly applied in the literature (ATZORI; FYALL; MILLER, 2018; BEC; MOYLE; MOYLE, 2019).
3. Qualitative indicators from secondary data that have no scoring standards are scored using a scorecard structure attributing weights according to an optimum (best desired condition) and worst (least desired condition) scale, considering the indicator's characteristic and ranging from minimum two values. E.g., biophysical characteristics scores 0, 0.34, 0.67, or 1 due to parameters established in the literature. Similar technique was applied by Leslie et al. (2015) when assessing the sustainability of social-ecological systems in Mexico.

To assess the robustness of indicators, the Principal Component Analysis, a multivariate data analysis technique, has been found useful in the construction or analysis of composite indicators. However, it requires a minimum number of values for each variable (at least four) to run the analysis, i.e., at least four destinations should provide with data (OECD, 2008). Indicators are aggregated according to affinities and to the outputs each of them generates to explain the respective dimension under measurement. For example, the 'infrastructure proximity to shoreline' determines the VUL/RES and better explains the 'built environment' dimension.

All indicators are equally weighted for two reasons. First, this simple method of aggregation is transparent and easy to understand, a criterion important for potential users (CUTTER; BURTON; EMRICH, 2010). Second, the literature

usually does not differentiate importance across indicators (KRISHNAMURTHY; LEWIS; CHOULARTON, 2014; LESLIE et al., 2015; SCOTT; HALL; GÖSSLING, 2019). While methods exist for determining weights (MARIN et al., 2021; ORENCIO; FUJII, 2013), they are subjective and do not always reflect the priorities of decision makers. The final score is given separately for each of the nine subindices, where the average of indicators determines the Coastourd Index final score. I understand that each dimension in the Coastourd Index provide different and place-specific comprehension of the drivers of VUL/RES in the destination, reason why results must be shown separately for better representation of the reality so that decision-makers easily identify the precise factors that need more attention or action(s).

3.3.2 Results

3.3.2.1 Detecting indicators for climate-related shocks and stressors experienced in the coastal zone

The DSF begins by identifying what the destination is vulnerable to i.e., the trigger event. Coastal destinations are susceptible to a variety of climate-related stressors (slow-onset events) and shocks (rapid-onset events) that destabilise the tourism system (see TURNER et al., 2003)). Identifying their characteristics and nature is the starting point when assessing VUL/RES of SES's. A literature review shows ten natural events that can enhance coastal destinations' vulnerability due to their respective potential direct and indirect impacts on destinations and tourists (BECKEN; HAY, 2012; CALGARO; DOMINEY-HOWES; LLOYD, 2014; COOMBES; JONES, 2010; DODMAN, 2009a; EHMER; HEYMANN, 2008; JIANG et al., 2015; ONAT; FRANCIS; KIM, 2018; PERCH-NIELSEN, 2010; ROSSELLÓ; BECKEN; SANTANA-GALLEGO, 2020; RYAN et al., 2018; SANTOS-LACUEVA et al., 2019a; SCOTT; GÖSSLING; HALL, 2012; SCOTT; HALL; GÖSSLING, 2019; SIMPSON et al., 2008; SINAY; CARTER, 2020; SUMMERS et al., 2017; UNEP, 2008). These climatic events are summarized in Table 3.3 and they can vary in magnitude, frequency, and duration (Calgaro et al, 2014; Toubes et al, 2017), and their probability to happen differ from place to place (see IPCC 2021 report, chapter 12). The

Table 3.3 – Potential impacts of natural events on coastal tourist destinations.

Event	Potential impacts for coastal tourist destinations	
	Direct and indirect impacts on destinations[1]	**Direct impacts on tourists[2]**
1. Sea level rise – SLR (Stressor)	• Inundation (permanently) • Salinization of freshwater sources • Beach width reduction • Erosion of coastal habitats	• Mobility (within and from/to the destination) • Freshwater shortage for tourists' activities and direct consumption (tourists might compete with residents) • Decreasing aesthetic value (attractiveness) • Reduction of beach space for tourists (e.g., for sunbathing or walking) • Personal injury, including risk of death • Displacement • Closure of attractions • Mobility (unable to leave or move around destination) • Loss of belongings
2. Storm surge (Shock) 3. Hurricane (Shock) 4. Earthquake (ground and tsunami) (Shock)	• Inundation (temporally) • Coastal/beach erosion (reduction in shoreline) • Damage and/or hazard to livelihoods and infrastructures • Salinization of freshwater sources • Displacement • Inundation by tsunami • Infrastructure disruption	
5. Wind blast (Shock)	• Damage and/or hazard to livelihoods – blown belongings that impact business, tourism infrastructures, and so on • Blown sand and dust	• Personal injury, including risk of death • Displacement of tents on camping and other infrastructures • Closure of attractions (e.g., cable car, kitesurf, paragliding)
6. Temperature (cold/heat waves and change in patterns) (Shock & stressor)	• Biodiversity loss • Altered agricultural production (e.g., food and wine tourism) • Increasing incidence of vector-borne (to varying degrees) • Changes in tourist flow (looking for colder/cooler/warmer weather) • Proliferation of insect diseases that can pressure the health system and raise operating costs due to employees' absence at work	• Environmental/heat stress • Physiological strain • Hypo- or hyperthermia • Climate discomfort • Increasing in aging disorders • Solar radiation impacts on health, suntan, sunburn • Insect illnesses and disturbances • In some cases, risk of death
7. Sea surface warming (Stressor)	• Warmer sea water in higher latitudes can attract more tourists, while lower latitudes might loose • Changes in biodiversity patterns (e.g., migration route of birds, turtles, whales, and dolphins) • Coral bleaching and biodiversity loss	• Climate comfort for swimming, diving, surfing, and other water activities • Loss of attractions leading to frustration (e.g., coral bleaching) • Physiological strain
8. Rainfall/ storms (change in patterns: intensity and frequency) (Stressor & shock)	• Changes in water availability • Floods, flash floods and landslides • Damage and/or hazard to livelihoods • Closure of airports	• Wetting • Reduced visibility (affect mobility) • Risk of injury • Interruption of attractions (e.g., landslide can cause closure of streets and roads, etc.)
9. Droughts & bushfires (Stressor & shock)	• Water shortage • Higher food price • Disruption of hydroelectricity • Bushfires (impact crops) • Migration of people and animals	• Water shortage for direct consumption • Closure of attractions: aquatic parks, pools, natural areas (National Parks, trails, etc.) • Loss of (biodiversity) attraction (e.g., bird and other wild animals for watching)
10. Hail (Shock)	• Damage to agriculture, vehicles, roofs, and other fragile structures	• Risk of injury • Closure of attractions

[1]All events have potential to negatively or, in few cases, positively impact destination's image (e.g., traditionally cold destinations can benefit from warmer weather).
[2]All events can impact the operating costs, which in turn increase prices for tourists, e.g., heating-cooling, snowmaking, irrigation, food and water supply, insurance costs.

extent to which the destinations might be adversely impacted will range according to the factors that drive destinations' VUL/RES and can be measured using the indicators proposed in the Coastourd Index.

3.3.3 Identifying indicators to quantify factors that affect destinations in coastal zones

By combining a range of contemporary perspectives from disaster risk reduction, resilience-thinking, sustainability science and geography, the DSF depicts the factors and processes that determine differential levels of VUL/RES in the destination under analysis in a given time. These factors are portrayed in three overarching dimensions: exposure, sensitivity, and system adaptiveness. However, to avoid literature conflicts regarding the exposure, sensitivity, and adaptation classification and concepts framed in DSF, the Coastourd Index notably focuses directly on the dimensions and their respective indicators. Therefore, nine subindices are presented and each of them comprises of up to nine indicators, illustrated in the diagram in Figure 3.2. Each indicator is given by an observable variable and a theoretical definition that illustrates the respective literature-based assumptions. Furthermore, the unit measurement with the ranking system is also presented in Table 3.4.

Figure 3.2 – Dimensions of Coastourd Index.

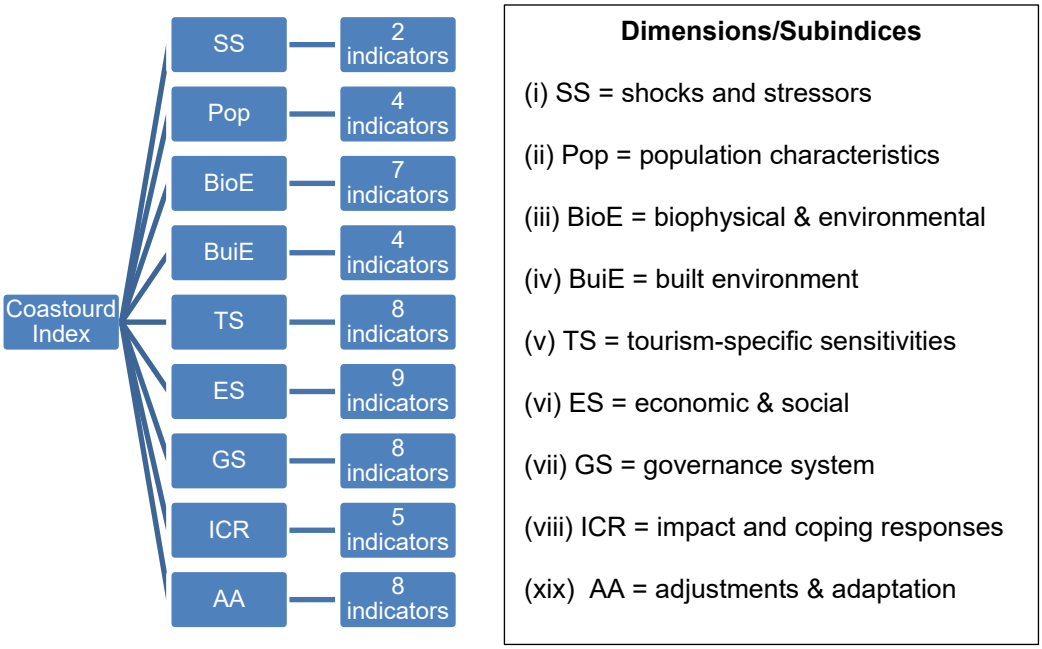


Table 3.4 – Coastourd Index indicators and unit measurement.

Coastourd Index			
Dimension	**Indicator**		**Measurement units, data category, and raking system**
	Observable variables	**Theoretical variables (Assumptions according to literature)**	
I. Shocks & stressors	1. Climate & natural events tendency	Extreme natural events are widely recognized as one of the greatest impacts of climate change and can damage tourism infrastructure and destination communities, deterring travellers during recovery and creating reputational damage (SCOTT; HALL; GÖSSLING, 2019)	Average of the tendency result for each event listed in Table 3.3 - 1.000- positive tendency - 0.000- stable or negative tendency (Secondary data)
	2. Attractions exposed	Attractions might be exposed to climate events (shocks and/or stressors). The more attractions are exposed more vulnerable the destination is to changes in climate.	Percentage of attractions exposed to potential impacts of climate events (Primary: interviews; and secondary data)
II. Population characteristics	3. Education	Education levels determine the extent to which a destination might be more flexible to cope with crisis and provide job opportunities, which reduce poverty and improve health, reducing vulnerability under climate constrains (CINNER et al., 2018)	UN Human Development Index: education In the absence of HDI for education in a local level, similar index can be used. The IFDM in Brazil measures education quality, school dropout, teachers' level of education, and so on.
	4. Poverty	Poverty is direct associated with high vulnerability since it reduces the capacity of society to adapt under climate constraints (SCOTT; HALL; GÖSSLING, 2019)	Percentage of inhabitants living in poverty (Secondary data)
	5. Working age population dependency	Low working dependency ratio of the population (higher proportion of working age adults) leads to higher coping ranges when tourism flows and therefore income falter due to hazards, reducing vulnerability (BORUFF; EMRICH; CUTTER, 2005; VINCENT, 2004)	Ratio of dependents per working age adults (Secondary data)
	6. Population density	Population density reduces resilience to the effects of climate change and presses extensive networks of critical infrastructure e.g., drainage system (ADGER et al., 2005; DODMAN, 2009b; IPCC, 2014, p. 551; LAZZARI et al., 2019)	Density relative to the state and region, if existent. (Secondary data). Note: There's no reference of an "ideal" density in the literature. Studies compare cities and find out a relatively low or high density.

continued

Table 3.4 - Continuing

Coastourd Index			
Dimension	**Indicator**		**Measurement units, data category, and raking system**
	Observable variables	**Theoretical variables (Assumptions according to literature)**	
III. Biophysical & environmental	7. Differences in the run-up heights	Topography plays a crucial role in increasing destination vulnerability under extreme natural events (CALGARO; DOMINEY-HOWES; LLOYD, 2014). Intensive rain fall can trigger landslides and flash floods associated with storm surge can inundate destinations on coast, affecting tourism infrastructures and causing damages to residents, business, and assets (TOUBES et al., 2017)	Percentage of the urbanized area susceptible to (a) landslide and (b) inundation. (Secondary data)
	8. Elevation above mean sea level	Low-elevation coastal zone (LECZ) areas – up to 10m high above mean sea level – are more vulnerable to SLR, storm surge, and tsunami. Models consider three LECZ scales: below 5m, 5-10m, and above 10m (IPCC, 2014, p. 366; KULP; STRAUSS, 2019; TOUBES et al., 2017)	Elevation average of the destination - 1.000- 0-5m - 0.500- 5.1-10m - 0.000- Above 10m (Secondary data)
	9. Coastal geomorphological characteristics	Sand and cobble beaches, delta areas, and estuaries are geomorphological features that increase the vulnerability to sea level rise (SLR) due to being more prone to inundation and risk of erosion than rocky cliffs or boulders beaches (DOUKAKIS, 2005; ONAT; FRANCIS; KIM, 2018). Classifications based on (THIELER; HAMMAR-KLOSE, 1999)	- 1.000- Barrier beaches, sand beaches, salt marsh, delta, mangrove, coral reefs - 0.750- Cobble beaches, estuary, lagoon - 0.500- Low cliffs, glacial drift, alluvial plains - 0.250- Medium cliffs, indented coast - 0.000- Rocky, cliffed coast, fjords (Primary: local observation; and secondary data)
	10. Biophysical characteristics	The physical function of the coral reef is as a wave reducer, the larger the coral reef area is, the greater is its function as wave reduction in that area. Coral reefs and coastal forests decrease exposure by reducing the energy of high-wave environments, ameliorating impacts of storm surges or waves (KURNIAWAN et al., 2016; ONAT; FRANCIS; KIM, 2018)	- 1.000- No coral reefs and coastal forests - 0.670- Low predominance of coral reefs OR coastal forests - 0.340- High predominance of coral reefs OR coastal forests - 0.000- Fully predominated by coral reefs AND coastal forests (Secondary data)

continued

Table 3.4 - Continuing

Coastourd Index			
Dimension	**Indicator**		**Measurement units, data category, and raking system**
	Observable variables	**Theoretical variables (Assumptions according to literature)**	
	11. Ecosystem diversity and health (marine & terrestrial)	Biodiversity is one mechanism that enhances resilience of SESs (including tourism) if species or functional groups respond differently to environmental fluctuations, so that declines in one group are compensated by increases in another (ADGER et al., 2005). E.g., reduction in fishery of some species can be compensated by other one in order to supply restaurants that serve for tourists.	Terrestrial: intactness index Marine: ocean index (dimensions: biodiversity, clean water, coastal protection, and carbon storage). (Secondary data) Note: indices available at a country level only. Local or regional data are desired.
	12. Sewer and water systems & waste collection	Sewer and water systems are essential for supporting other forms of development activities, including those related to tourism (FREDUAH; FIDELMAN; SMITH, 2019). Appropriate waste disposal avoids localised and regional degradation of the natural environment including pollution of beaches and sea, lakes, or other tourism attractions, reducing vulnerability of the destination.	1 minus percentage of inhabitants supplied by sanitary system (Secondary data)
	13. Blue flag award	Recognised by UNESCO, Blue Flag is a world-renowned eco-label certification for beaches, marinas, and boats. Beach destinations that receive such award demonstrate compliance to four main requirements: environmental education and information, water quality, environmental management, and safety & services. By pursuing such criteria, destinations develop strategies that contribute to increase resilience, therefore, to reduce vulnerability to climate change.	1 minus percentage of beaches and marinas holding Blue Flag certificate (Secondary data)

continued

Table 3.4 - Continuing

Coastourd Index			
Dimension	**Indicator**		**Measurement units, data category, and raking system**
	Observable variables	**Theoretical variables (Assumptions according to literature)**	
IV. Built environment	14. Infrastructure proximity to the shoreline	Distance from shoreline is one factor that determine the extent to which climate events such as sea level rise and storm surges can impact destination's infrastructures (PERCH-NIELSEN, 2010)	- 1.000- Close to shoreline. Waves can reach or even cause damage to infrastructures very often including flooding - 0.500- There is some safe distance, but strong waves might cause some damage - 0.000- Settlements are distant enough to keep infrastructure safe from natural fluctuations (Primary data: local observation and interviews)
	15. Quality of tourism infrastructure	The type (wooden timber or steel/concrete) and maintenance of built structures might either reduce or increase vulnerability of destinations to the effects of damaging natural hazard events such as tsunamis and strong wind associated with tropical cyclones (JIANG et al., 2015; SPECHT, 2008)	- 1.000- Great majority of the structures are simple, built by timber and other less permanent infrastructure - 0.500- Structures are partially built using hard and soft materials - 0.000- Great majority of the structures are made by steel and concrete (Primary data: local observation)
	16. Transportation infrastructure	Investments in transportation infrastructure such as roads, airports, and water- and railways may increase people's assets by improving access to markets, which in turn affect tourist arrival numbers, and serve as a catalyst for other types of development (for example, access to education and healthcare) that can provide greater flexibility and agency to manage climate shocks in the destination (CINNER et al., 2018; CROTTI; MISRAHI, 2015; JIANG et al., 2015).	The destination has… - 1.000- …only one transport option available and access is difficult due to bed quality of the infrastructure - 0.670- …few transport options but it lacks maintenance and infrastructure needs higher improvements in quality - 0.340- …good transport options for domestic markets but needs some maintenance and/or improvements - 0.000- …a variety of transport options for domestic and international markets, and in good quality

continued

Table 3.4 - Continuing

Coastourd Index			
Dimension	**Indicator**		**Measurement units, data category, and raking system**
	Observable variables	**Theoretical variables (Assumptions according to literature)**	
	17. ICTs & electricity infrastructures	Information and Communication Technologies (ICTs) are pervasive and important for all sectors; it is considered part of the general enabling environment. For example, internet is essential for marketing, travel wholesalers, newspapers and magazines, all of which important for destinations. Electricity blackouts have a negative impact on ICTs use as well as on food stock, cooling/heating and other electrical-dependent activities (CROTTI; MISRAHI, 2015; FILIMONAU; DE COTEAU, 2020; JIANG et al., 2015). Additionally, ICTs are crucial to run warning systems in case of disasters, e.g., for communication.	The destination has… - 1.000- …lack of electricity and ICT infrastructure. Interruptions in services occur frequently - 0.670- …to improve the quality of either ICT or power infrastructure - 0.340- …enough power and ICT infrastructures for the current demand. It occurs some interruptions occasionally - 0.000- …very good power and ICT infrastructures (mobile and fibber networks), enabling opportunities for new business and/or expansion (Primary data: interviews)
V. Tourism-specific sensitivities	18. Tourism seasonality	Climate change may affect considerably the tourism flux around de globe, changing seasonality patterns (SCOTT; HALL; GÖSSLING, 2019). High seasonality impacts in long-term planning, reducing loss of opportunities to business development and creation of jobs (SANTOS-LACUEVA et al., 2019b). The more the tourism flux is equally distributed along the year less sensitive the destination is to ENEs that might affect high seasons.	Standard deviation – SD (monthly series) - 1.000- Very high (CV 1.76+) - 0.750- (CV 1.31 - 1.75) - 0.500- (CV 0.91 - 1.30) - 0.250- (CV 0.46 - 0.90) - 0.000- Very low (CV 0 - 0.45) (Secondary data)
	19. Diversity of tourism markets	The more varied and equally distributed the markets, the more likely that if one market slows down another can take its place or at least keep enough income coming in to keep it going until other markets can be secured. Note: distribution of tourism flux by origin: domestic and internationally).	Standard deviation (SD) in relation to: (a) number of cities/regions in the state (intrastate) and states within the country (interstate); and (b) the five most emitter markets (in USD) in the continent - 1.000- Very high (SD 1.76+) - 0.750- (SD 1.31 - 1.75)

continued

Coastourd Index			
Dimension	**Indicator**		**Measurement units, data category, and raking system**
	Observable variables	**Theoretical variables (Assumptions according to literature)**	
			- 0.500- (SD 0.91 - 1.30) - 0.250- (SD 0.46 - 0.90) - 0.000- Very low (SD 0 - 0.45) (a: Primary or secondary data; b: data.worldbank.org)
	20. Reliance on international tourism	Destinations with an over-reliance on domestic or international demand are more exposed to economic and geo-political risks. Some destinations which are highly reliant on domestic demand could be exposed to changes in the domestic economy. On the other hand, those which are more reliant on international demand and/or on particular source markets may be vulnerable to external disruptions e.g., Covid-19 (WTTC, 2019).	Rate for international vs. domestic flow. 1 minus (intl/dmtc) An equilibrium rate (0.5/0.5) would be ideal even though it does not represent the real world. However, it is a parameter to guide strategic planning, similar to GINI index to guide countries to pursue inequality reduction, even though we all know that no country in the world can reach 100% equality. (Primary or secondary data)
	21. Diversity of products	Diversification strategies identify alternative new sectors in response to the decline of others and reduce risk of demand shock, increasing communities' flexibility, this is, their capacity to adapt to climate risk (LOEHR, 2020; SANTOS-LACUEVA et al., 2019b; WEIDENFELD, 2018).	- 1.000- only one tourism segment (e.g., beach or ecotourism) - 0.670- 2-3 segments (e.g., beach, ecotourism, and/or cultural) - 0.340- 4-5 segments (e.g., beach, ecotourism, cultural, night life and/or adventure) - 0.000- 6 plus segments (Secondary data: exploratory research)
	22. DMO - Destination Marketing Organisation activity	DMOs play a very important role to destination's positioning and success (PIKE, 2017; VOLGGER; PECHLANER, 2014). An active and purposeful DMO has a network capability to help destination to better respond and cope with crisis during climate hazards.	- 1.00- inexistent - 0.67- it exists but not purposeful - 0.34- it exists and it is a little purposeful - 0.00- it is active and very purposeful (Primary: interviews; and secondary data)

continued

Table 3.4 – Continuing

Coastourd Index			
Dimension	**Indicator**		**Measurement units, data category, and raking system**
	Observable variables	**Theoretical variables (Assumptions according to literature)**	
	23. Destination's history & positioning	Butler's (2005) Tourism Area Life Cycle model outlines six specific stages in the dynamic process of tourism development. Changes in tourism numbers can happen due to marketing and media, changes in taste, and external influences such as natural disasters or terrorism. I assume that in the 'rejuvenation' stage the destination has capability to adapt and reinvent, even under constrains such as changes in climate.	- 1.000- exploration - 0.800- involvement - 0.600- development - 0.400- consolidation/decline - 0.200- stagnation/stabilization - 0.000- rejuvenation (Primary: interviews; and secondary data)
	24. Destination image – brand position	Developmental history and market positioning strategies help destinations to be noticed among the crowd of competitors and stand for something meaningful in the minds of target consumers, which in turn increase resilience and the ability of destinations to recover from disasters (CALGARO; DOMINEY-HOWES; LLOYD, 2014; PIKE; MASON, 2011).	Average of Likert scale responses to identify the: a) Destination's desirability for tourists b) Destination's positive/negative image c) Revisiting rate (Primary: interview/survey; or secondary data)
	25. Tourists' perceptions of climate risk	Risk perception plays a very important role in the consumer choice process, making tourism very image sensitive about climate change risks (e.g., hurricane). Destinations are cautious about even acknowledging such risks for fear of adversely affecting their reputation (FILIMONAU; DE COTEAU, 2020; SCOTT; GÖSSLING; HALL, 2012; WALTERS; MAIR; LIM, 2016).	Percentage of respondents to climate risk questions (see Appendix B for questionnaire) (Primary data: survey)
VI. Economic & social	26. Economic diversity	Low diverse economies may impact even tourist destinations highly developed, which can suffer from vulnerability and lack of resilience to climate change (BIGGS et al., 2015).	1 minus percentage of the 11 World Bank (2016) economic activities composing the destination's GDP - 1.000- 1 sector (~9%) - 0.000- 11 sectors (100%) (Secondary data)

continued

Table 3.4 – Continuing

Coastourd Index			
Dimension	**Indicator**		**Measurement units, data category, and raking system**
	Observable variables	**Theoretical variables (Assumptions according to literature)**	
	27. Financial capital availability	Key underlying determinants of resilience are the availability of financial capital in times of need (CINNER et al., 2018), such as Covid-19 or natural disasters.	1 minus percentage of months (within a year) the tourism industry can keep business running in case of a crisis. Note: 12 months = 100% (1) (Primary data: survey)
	28. Business Insurance	Insurance is a key driver for recovering from a disaster event because it maintains business resilience since it covers losses in income and certain assets (e.g., a hotel building and its furniture in case of flooding or hurricane) (BEC; MOYLE; MOYLE, 2019; HALL; PRAYAG; AMORE, 2017).	Average of responses of the tourism industry holding insurance. - 1.000- No, it does not have any insurance - 0.500- Yes, but it covers either assets or income losses - 0.000- Yes, it covers assets and income losses (Primary data: survey/interview)
	29. Credit access	Limited access to economic capital can reduce resilience due to lack of adaptation capacity to recover from natural hazards (BEC; MOYLE; MOYLE, 2019; JIANG et al., 2015).	Average of responses of the tourism industry with - 1.000- No credit history with any agent and no family or friends to draw upon - 0.000- easy access to get loans (from financial institutions, family members, and/or friends) (Primary data: survey/interview)
	30. Job security & welfare safety nets	Formal jobs establish a stable relationship that keep staff on the industry and run businesses constantly benefiting both employers and employees. Formally employed workers have access to social security systems, increasing their resilience during crisis, and business avoid fluctuations in staff since workers prefer stable jobs instead seasonal ones (CALGARO; DOMINEY-HOWES; LLOYD, 2014; JIANG et al., 2015).	1 minus formal employment rate in tourism (Primary or secondary data)

continued

Table 3.4 – Continuing

Coastourd Index			
Dimension	**Indicator**		**Measurement units, data category, and raking system**
	Observable variables	**Theoretical variables (Assumptions according to literature)**	
	31. Local ownership	Foreign ownership repatriates most of the tourist expenditures that could be used to boost the quality of life of locals (LOEHR, 2020; SCHEYVENS; MOMSEN, 2008). Local owner-operators can develop an emotional attachment to their businesses, associated to the sense of place, identity and lifestyle, with benefits beyond reducing exposure to CC, but also increase the potential to strength their resilience under any constraints (BIGGS et al., 2015; MCNAMARA et al., 2020).	Percentage of non-locals owning business (Primary data: interviews or secondary data)
	32. Destination's expertise	Entrepreneurships can struggle with business due to lack of local technical skills and inadequate levels of human capital, fundamental factor for tourism development. Local government also can face similar problems generating poor policies or even lack of actions, increasing destinations sensitivity (CALGARO; DOMINEY-HOWES; LLOYD, 2014; CROTTI; MISRAHI, 2015; JIANG et al., 2015; VAN DER VEEKEN et al., 2016).	Average of Likert scale to the question: Q. This institution can easily hire a qualified employee when needed. (Primary data: interviews)
	33. Population working in tourism	The rate of population whose income depends on tourism makes destinations less or more exposed to the adverse climate events.	Percentage of workers with income relying on tourism-related field (Secondary data)

continued

Table 3.4 – Continuing

Coastourd Index			
Dimension	**Indicator**		**Measurement units, data category, and raking system**
	Observable variables	**Theoretical variables (Assumptions according to literature)**	
	34. Kinship networks and groups	Kinship networks and groups can reduce vulnerability in times of need because people can access support from family members, friends, or their employers (CALGARO; DOMINEY-HOWES; LLOYD, 2014; FILIMONAU; DE COTEAU, 2020).	Average of Likert scale responses: In time of crisis and/or if a disaster affects my livelihood – house, job, or income source – I can truly rely on members of my family, friends or even employers to help me overcome hard times. (Primary: interview/survey)
VII. Governance processes	35. Access to natural attractions & resources	Resorts usually take beaches from locals, excluding them from small business opportunities (food/drink sales), fishery, and other natural resources important for livelihoods, adversely affecting the sustainability of the SES (OSTROM, 2009). Note: resources include beaches, waterfalls, biodiversity, fishery, forest, etc.	Average of responses. The access to resources is: - 1.000- Controlled by one or very few groups. Not accessible to others. - 0.500- Controlled by few groups. Not easily accessible - 0.000- Democratically controlled, organised and accessible to all according to rules. (Primary data: interviews)
	36. Transparency	Government transparency contributes to compliance and law enforcement reducing potential destabilizations within the SES throughout planning exceptions, nepotism, corruption, intimidation, self-censorship, and inequality, factors that affect the destination's VUL/RES (CALGARO; DOMINEY-HOWES; LLOYD, 2014).	Average of Likert scale responses: Are the decision-making processes transparent? Note: Available data such as indices to measure government transparency can also be used. (Primary: interview/survey; and/or secondary data)
	37. Participation in Decision-making Processes	Governance structure that allows participation and involvement of multi-stakeholders affected in the decision-making process give legitimacy and transparency, creating opportunities for assigning responsibilities (integrated management), which in turn improve responses to crisis, increasing destinations' resilience (JIANG et al., 2015; SANTOS-LACUEVA et al., 2019b; SCHMITT, 2011; UNDRR, 2017).	Average of Likert scale responses to the question: Destination has mechanisms to allow representativeness of stakeholders for making tourism-related decisions (For example, tourism strategic plans or regulations: to start a new business; to access natural/artificial resources; to decide about land zoning, business hours for clubs, bars, etc.) (Primary data: interview/survey)

continued

Table 3.4 – Continuing

Coastourd Index			
Dimension	**Indicator**		**Measurement units, data category, and raking system**
	Observable variables	**Theoretical variables (Assumptions according to literature)**	
	38. Destination trustworthiness	Governance culture relates to trust versus mistrust between actors, their different points of view, views of the governance process, degree to which is oriented by normative goals and procedural rules, and opportunities for civil society actors to influence processes and results (SCHMITT, 2011).	Average of Likert scale responses to the question: I completely trust in working and/or doing business in this destination. People are trustable, partners including government comply with the agreements and when a conflict of interest raises, local governance arrangements or subnational/national institutions act fairly to solve conflicts. (Primary data: interview/survey)
	39. Political & civil stability	Solid institutions and strong governance mechanisms allow high capacity to deal with crisis and confine the impact to manageable proportions, reducing vulnerability and increasing resilience (ADGER et al., 2005). Stability also determines attraction of investments (SANTOS-LACUEVA et al., 2019).	Average of Likert scale responses to the question: Institutions and organizations (government, justice, legislative power, and representative NGO's,) have decisions respected and conflicts solved throughout democratic and fair mechanisms that consider small and big groups equitably. (Primary: interview; and secondary data: exploratory research)
	40. Flexibility (autonomy)	Flexible governance through decentralization and autonomy improves destination's capacity to cope with hazards. For example, under sudden changes (shocks) responses at a local scale produce the best resilient results, allowing social actors to autonomously self-organise, review, and adjust their institutions in response to shocks (DOGRU et al., 2019; FIDELMAN et al., 2017; LUTHE; WYSS, 2014).	Average of Likert scale responses to the question: Actors have autonomy to make decisions at different scale levels (e.g., beach spatial organisation, opening hours for clubs, reorganization of parking slot for taxi during or after a flood, etc.). (Primary data: interview/survey)
	41. Government accountability	Healthy fiscal position would allow governments adjust taxation and expenditure policies in the face of adverse impacts (BRIGUGLIO et al., 2008).	Ratio between expenditures x revenues - 1.000- Expenditure overpasses 90% of revenues - 0.500- Expenditure represents 75-90% of revenues - 0.000- Expenditure represents up to 74.99% of revenues

continued

Table 3.4 – Continuing

Coastourd Index			
Dimension	**Indicator**		**Measurement units, data category, and raking system**
	Observable variables	**Theoretical variables (Assumptions according to literature)**	
	42. Government responsibilities for natural disaster	Clear definition of competences and sharing responsibilities on the coastal domain among stakeholders and the different scale levels of government is crucial to reduce vulnerability to climate-associated hazards and to increase adaptability since a perceived lack of responsibility for dealing with crises cause inaction (BECKEN; HUGHEY, 2013; FIDELMAN et al., 2017; TOUBES et al., 2017).	Average of Likert scale responses to the question: Are the management arrangements clear and characterised by decentralised and shared responsibilities (cooperation) between all scale levels (local to national)? (Primary: interview; and secondary data: exploratory research)
VIII. Impact and coping responses	43. Emergency Plan (EP)	Integrating tourism into emergency structures and processes allow integrative responses, then contribute to build resilience and higher capacity to deal with external shocks since prevention is of utmost importance to use the development potential of tourism (ADGER et al., 2005; BECKEN; HUGHEY, 2013; FILIMONAU; DE COTEAU, 2020; UNDRR, 2017).	Average of responses: Does the destination have a public emergency plan, e.g., DRR? - 1.000- No - 0.750- Yes but not integrated with tourism - 0.500- Yes but do not fully institutionalize tourism emergency structures - 0.250- Yes but Tourism EP is separated - 0.000- Yes and it includes tourism as a mainstream (Primary: interview; and secondary data: exploratory research)
	44. EP for tourism industry	A Tourism Action Plan (preparedness) increase resilience in the industry (e.g., prepare buildings to cope with tropical cyclone, protocols for hotel sector and staff trained in case of floods or heatwaves) (BECKEN; HUGHEY, 2013; UNEP, 2008).	Average of responses to the question: Does the business/company have EP? - 1.000- No - 0.670- Yes, but it requires to build infrastructure AND to train staff - 0.340- Yes, but it requires to build infrastructure OR to train staff - 0.000- Yes, the infrastructure required is built and staff are trained and prepared for expected hazards (Primary data: interview/survey)

continued

Table 3.4 – Continuing

Coastourd Index			
Dimension	**Indicator**		**Measurement units, data category, and raking system**
	Observable variables	**Theoretical variables (Assumptions according to literature)**	
	45. Warning system	Clear communication (what/how/when) of potential disaster (prediction) between meteorological agencies, media, emergency services, industry, and civil society pre, during, and after disaster support decision-makers to take the best actions, including early evacuation if needed, then increase resilience (BECKEN; HUGHEY, 2013; JIANG et al., 2015; SPECHT, 2008; STUDENT; LAMERS; AMELUNG, 2020).	Average of Likert scale responses to the question: - 1.00- The tourism industry/government/institutions do not have any warning system, or it is not aware of any risk - 0.000- The tourism industry/government/institution warning system comprise early warnings, good network for communication pre-, during, and post-disaster (Primary data: interview/survey)
	46. Responsiveness	Actions taken immediately before, during or directly after an emergency, to save lives and property in a timely manner include emergency evacuation, rescue people (including tourists), guarantee safety, food, shelter, medical assistance, clearance of roads for supplies and people, traffic management, reestablishment of communications, and accurate information to avoid more disaster (BECKEN; HUGHEY, 2013).	Likert scale responses to the question: - 1.00- No roles defined and no coordination. - 0.000- Destination has clear identification and coordination of pre- and post-event roles, supported by regular training. Roles agreed and signed off. (Primary data: interview/survey)
	47. Immediate recovery	Restore core infrastructures (electricity, water and sewer systems, ICTs), fast clean-up after damage, repair lives and towns after disaster, provide economic assistance for business in case of severe economic breakdown, and communicate markets that tourism activities are back on operation are crucial to increase resilience of the destination (BECKEN; HUGHEY, 2013; FILIMONAU; DE COTEAU, 2020).	Percentage of the destination rebuilt/restored and prepared to receive visitors again within a year (Primary: interview/survey; or secondary data)

continued

Table 3.4 – Continuing

Coastourd Index			
Dimension	**Indicator**		**Measurement units, data category, and raking system**
	Observable variables	**Theoretical variables (Assumptions according to literature)**	
IX. Adjustments & adaptation	48. Monitoring of emergency plan	Evaluation and monitoring of coping strategies to guarantee that pre-existing vulnerable situations are not returned and that the prediction of the likely occurrence of climate events, together with knowledge of their effects in the past, anticipate changes to develop strategies to respond to (CINNER et al., 2018; SPECHT, 2008).	-1.000- No review has been undertaken or DRR plan inexistent. -0.670- No review has happened yet, but a review is assumed, despite no timescale has been set out. -0.340- The plan has already been reviewed and updated and there is a published commitment to regular review. -0.000- The plan has been reviewed and there is a published commitment to review it at least every 3 years. Processes to capture lessons learnt have been integrated. (Primary: interview/survey; and secondary data: exploratory research)
	49. Information on risks & trends	Raise awareness about the likelihood of an extreme natural event, its nature and likely effects is vital to minimise risk in the short- and long-terms (BECKEN; HUGHEY, 2013; FILIMONAU; DE COTEAU, 2020; SPECHT, 2008; TOUBES et al., 2017).	Average of Likert scale responses: - 1.000- No awareness about current and future risks posed by climate events - 0.000- Highly aware about current and future risks posed by climate events (Primary: interview/survey)
	50. Public budget allocation for DRR	Allocation of financial resources in all scale levels to execute DRR actions are determinants of adaptive capacity of coping with climate-associated hazards (CINNER et al., 2018; UNDRR, 2017).	Budget for DRR. (Weights: local level = 0.5; subnational and national = 0.25 each) - 1.000- No - 0.000- Yes (Secondary data: exploratory research)

continued

Table 3.4 – Continuing

Coastourd Index			
Dimension	**Indicator**		**Measurement units, data category, and raking system**
	Observable variables	**Theoretical variables (Assumptions according to literature)**	
	51. Policy and planning interventions for tourism integration	Policy interventions can facilitate the rebuilding of housing and infrastructure after a disaster (Cinner et al, 2018) and a risk management plan linking tourism to other planning processes to mitigate the risks and hazards increase destinations resilience (SANTOS-LACUEVA et al., 2019b; SIMPSON et al., 2008).	Average of Likert scale responses to the question: - 1.000- Nothing has changed in the past 20 years - 0.000- City planning and policies interventions fully integrate tourism, CC, and disasters issues (Secondary data: exploratory research)
	52. Climate policies	Climate policies are essential to cope with challenges posed by CC in tourist destinations, increasing their resilience (SANTOS-LACUEVA et al., 2019b).	-1.000- Destination has no local CC policy. -0.670- CC plan needs to be updated OR integrated tourism industry. -0.340- CC plan integrates the tourism industry but lack updating. -0.000- Updated CC plan that integrates the tourism industry and offers opportunity for mitigation actions (e.g., water consumption reduction, green energy, strategies to reduce CO_2 emission). (Secondary data: exploratory research)
	53. Biophysical reorganization	Destination's resilience increases by implementing (new) land zoning management as well as adequate infrastructure and strategies that includes architectural techniques and proper materials to improve resistance to destructive climate events (PROVITOLO; REGHEZZA-ZITT, 2015; UNDRR, 2017).	-1.000- No land use planning, no building regulations, and no adequacy of infrastructure. -0.670- Land use management, building regulations, and infrastructures planned, but not in place. -0.340- Land use management and building code not reviewed or do not integrate climate risk and infrastructure strategies -0.000- Land use management and building code reviewed, comprising respectively land zoning and material and other building regulations that integrates climate risk and infrastructure strategies (adaptation). (Secondary data: exploratory research)

continued

Table 3.4 – Conclusion

Coastourd Index			
Dimension	**Indicator**		**Measurement units, data category, and raking system**
	Observable variables	**Theoretical variables (Assumptions according to literature)**	
	54. Flexibility of the industry to changes	Individuals with more flexibility to change are better able to adapt to climatic impacts (BIGGS et al., 2015; CINNER et al., 2018). E.g., the flexibility to diversify livelihood sources and/or markets and/or nature of the product i.e., create new attractions to compensate loss of beach(es) targeting new markets.	Average of Likert scale responses: In case of 50% slump for 12 months in destination's visitor numbers, would you/business have another source or potential job to keep income coming to compensate such a loss? (Primary: interview/survey)
	55. Disaster risk learning and exchange	Learning from past events and/or other places are crucial for reducing vulnerabilities and multi- and cross-scale institutional processes, including collaboration between multiple stakeholders, can ensure flexibility, an important property for adaptation of SES as tourism (BASURTO; GELCICH; OSTROM, 2013; CINNER et al., 2018; LUTHE; WYSS, 2016)	Average of responses to Likert scale -1.000- No attempt to learn from past success and failures and no exchange with others (places, institutions, governments, etc.) Vulnerabilities remain unchanged. -0.000- Platforms and processes established to keep regular (at least annually) exchanges with other institutions (e.g., other destinations or states/countries), to share experiences and capture resilience best practices (e.g., forums for risk management), considering all stakeholders, including tourism industry. (Primary: interview; or secondary data: exploratory research)

Source: author

3.4 Concluding remarks

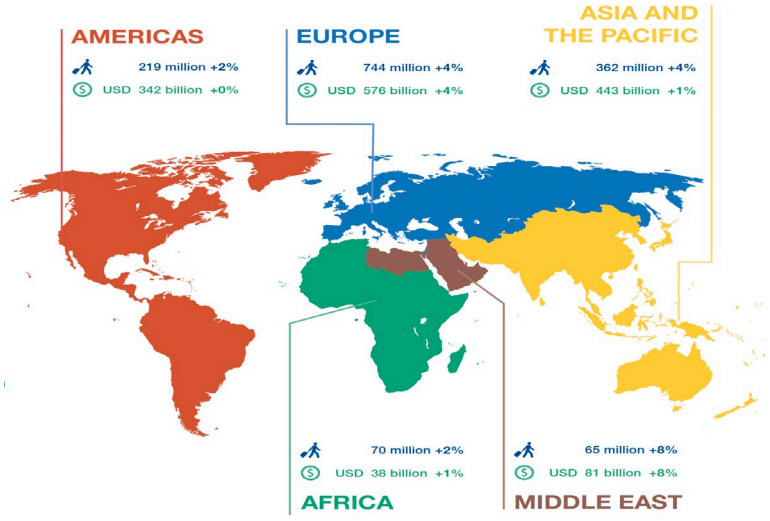
Several studies have endeavoured to assess the VUL/RES of communities, cities, or countries in the context of climate and related disasters. However, most of them focuses solely on the qualitative factors that influence the system under investigation. A reasonable explanation is that combining quantitative approach with qualitative analysis proved challenging. This chapter aimed to develop the first tool in the tourism and climate change context to assess the VUL/RES of coastal tourist destinations at a local level. Based on a profound literature review, the chapter presented the Coastourd Index comprised of nine dimensions and 55 indicators that might capture the main nuances and drivers of VUL/RES. The theoretical assumptions detailed in each indicator allow interpretations for (quantitative) grounded metrics validated with qualitative data regarding each dimension to better understand the tourism SES under analysis. This integration of both qualitative and quantitative methods provides a complete assessment of the VUL/RES factors within the tourist destination in which the index can be applied.

4 APPLICATION OF THE COASTOURD INDEX, THE COASTAL TOURIST DESTINATION VULNERABILITY AND RESILIENCE INDEX TO CLIMATE CHANGE: AN ASSESSMENT OF BALNEÁRIO CAMBORIÚ, BRAZIL

4.1 Introduction

Tourism has reached an important level in the global scenario in the past decades. The international tourism flow increased from 25 million visitors across the world in 1950 to more than 1.4 billion by the end of 2019 (before Covid-19), accounting to approximately US$1.48 trillion that represent 7% of total global exports, 28% of services exports, 10% of the global GDP, and one in ten jobs created on the planet (UNWTO, 2021; WTTC, 2021). Figure 4.1 shows that Europe receives the great majority of the international flow (51% in 2019), followed by Southeast Asia and The Pacific (25%), The Americas (15%), Africa (5%) and Middle East (4%). The share of visitors travelling for leisure and recreational purpose are 56% (2018) using air travel as the main transport (58%), followed by road 37% (*ibid*).

Figure 4.1 – Map of international tourist arrivals (million) and tourism receipts (USD billion).



Source: UNWTO (2021).

Brazil ranks 62nd place in the world ranking of most visited countries, receiving about 6.3 million international tourists or 0.5% of the international flow. That adds about US$6.1 billion to the country's foreign exchange balance, 0.5% of

the global amount (2019 based; data.worldbank.org). Comparing to its size in South American territory (48% of the land), the country receives only 20% of the region's international flow. However, the domestic market is expressive, with more than 62 million travellers a year, of which 67% travel for leisure purposes (arrivals including visiting to family and friends), and 34% of this look for sun, sand, and sea (3S) tourism, 27% prefer cultural places and 25% enjoy nature-related activities such as ecotourism and adventure (IBGE, 2020).

The most visited destinations are coastal cities. This includes Rio de Janeiro, Salvador, Fortaleza, Natal, Recife, Florianópolis, Balneário Camboriú, and the Baixada Santista region (Guarujá, Praia Grande, Santos, and São Vicente). All of them suffer from the effects of coastal floods from storm surges and may experience the impacts of climate change to varying degrees, challenging the vulnerability and resilience (VUL/RES) of Brazilian destinations (DA SILVA SANTOS; MARENGO, 2020; PBMC, 2016).

Tourism also represents 12% of the Santa Catarina (SC) GDP, the most visited state in Southern Brazil for 3S tourism (VIEIRA; MENESES; KELLER, 2020). This state has experienced a significant growth in the number of disasters caused by natural events that might impact its tourism. From 2000 to 2010 droughts has increased by 76%, abrupt floods 74% and wind blast 53% (PBMC, 2016). The state also presents a medium potential for wind speed of up to 102 km/h and the average wave height across the state has also risen, with historical trend of the mean sea level estimated at 2.11 mm/year, totalling more than 10 cm over a 50-year period (1960-2010) (*ibid*). Extreme climate events frequently cause damage, such as storm surges that has deposited approximately 2-4 thousand m^3 of sand on the main Avenue of Balneário Camboriú (BC) in 2016 (DA SILVA SANTOS; MARENGO, 2020; PBMC, 2016). BC contributes secondly to the tourism flow of SC, hosting about 1.5 million visitors only during a summer (MANNRICH; RUIZ; ANJOS, 2017). The city is the favourite Brazilian destination for tourists coming from Argentina.

I use the Coastourd Index (subsection 3.3) to assess the vulnerability and resilience (VUL/RES) of Balneário Camboriú to climate change. This city was

chosen for this case study because it is the second most visited destination in SC. The assessment is aimed at identifying the main factors of and to what extent they contribute to (increase/reduce) VUL/RES to the changes in climate. The operationalisation of the Coastourd Index also enables to: (a) test the usefulness of the new index in understanding VUL/RES drivers at a local context; and (b) assess its potential to quantitatively track changes and compare destinations in the future over space and time. This later represents a crucial step to advance the combined qualitative and quantitative methods in tourism science. I begin by introducing the case study and summarising the main climate events that impact the destination or have potential to. Then, an overview of the methods is provided followed by the findings.

4.2 Material and methods

For this study, indicators are equally weighted as explained on section 3.3.1.3. The score values for all indicators in Coastourd Index are between zero and one, where the desired condition is zero, whilst 1.00 expresses maximum vulnerability and minimum resilience. The results are classified into a five-level scale (Table 4.1). Each indicator is identified with a code number to easily match with the indicator's list (e.g., indicator 1 = i1) and the respective calculus and data source are detailed in the Appendix A.

Table 4.1 – Coastourd Index Scale Levels.

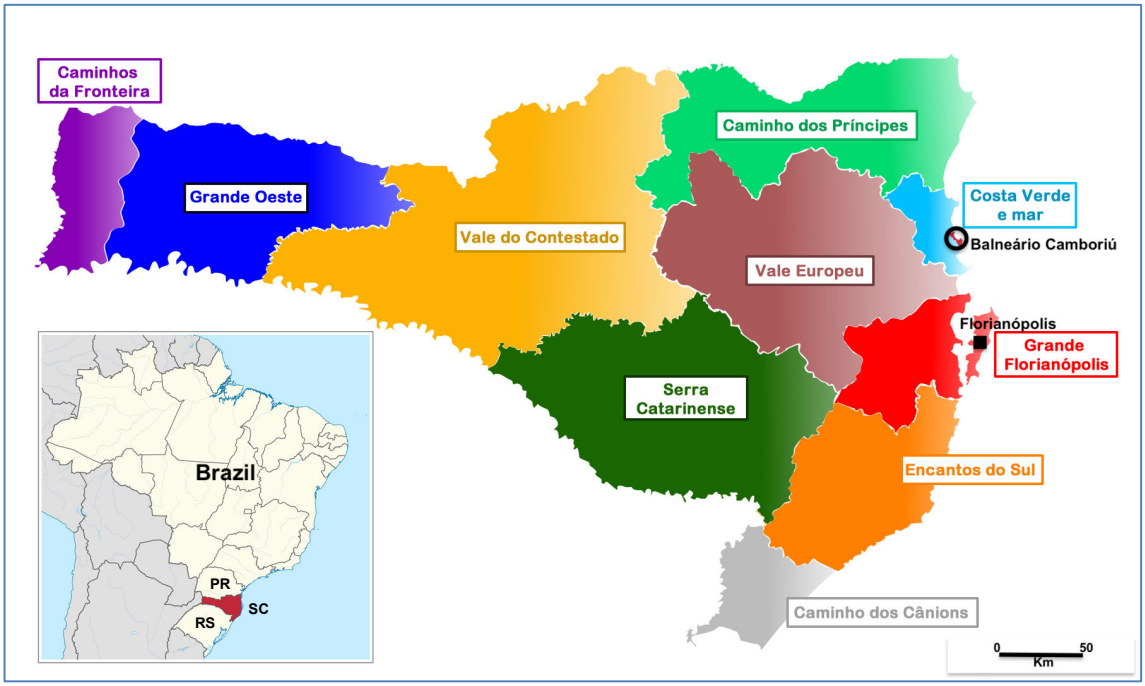
Score	Level
0.801 - 1.000	Very high
0.601 - 0.800	High
0.401 - 0.600	Medium
0.201 - 0.400	Low
0.000 - 0.200	Very low

4.2.1 Study area

Located 83 Km from the state capital of Florianópolis, the destination of BC is part of the Costa Verde & Mar (Green Coast & Sea), a beach tourism region of nine municipalities on the Central North coast of Santa Catarina (SC) state

(Figure 4.2). Its developmental history as a tourist destination dates back to the late 1920s, when the scenic landscape and beaches became the favourite place for swimmers in the region, giving rise to set up the first hotel in 1928 (SCHLICKMANN, 2016). Four decades later (1964) the district achieves its independence (*ibid*), starting a promising tourism development where many buildings have been gradually shaping the city's coastline, as shown in the Figure 4.3.

Figure 4.2 – Balneário Camboriú location in the Costa Verde e Mar tourism region.

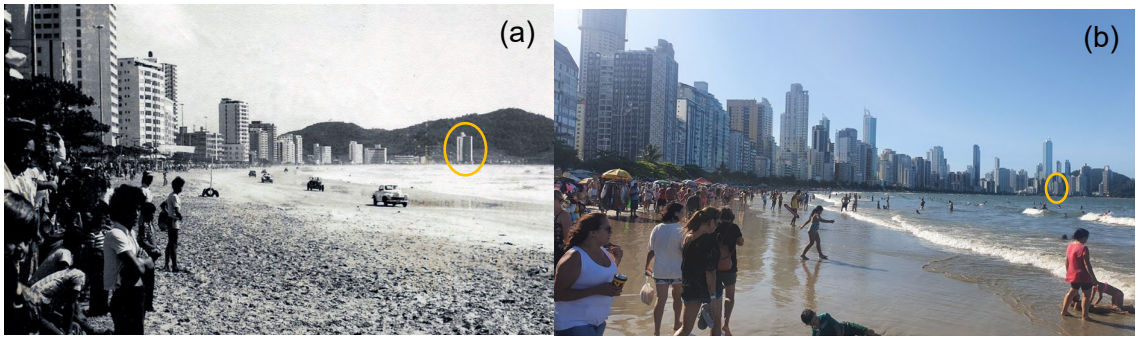


Source: ViagemSC (2022).

Today, BC has the highest population density of the three Southern states of Brazil (PR - Paraná, RS - Rio Grande do Sul, and SC - Santa Catarina), and it is the most established destination in its tourism region, where modern buildings blend into the natural landscape, providing good urban infrastructure with a capacity of 7883 accommodation rooms (SECTUR, 2019). The high-level rates in health and security (ranking the fourth place in the 2010 UN-HDI for the 5565 Brazilian municipalities) are one of the main factors that contribute to attract the 3.8 million visitors a year (PMT, 2019). This flow adds approximately BRL 3.3 billion in the local economy (USD 830 millions in 2019 rate) (FECOMÉRCIO, 2020) that accounts for 13% of BC's GDP (2019 GDP; cidades.ibge.gov.br),

making tourism the principal source of revenue. The main attractions include beach activities, nightlife, shopping, and parks, which are also located in the neighbour destinations, such as the largest Latin American amusement park in Penha city (Beto Carrero) and some astonishing beaches in Bombinhas city.

Figure 4.3 – Balneário Camboriú during the 1970's and 2020's.



Decades of (a) 1970 and (b) 2020
Source: (a) Schlickmann (2016); (b) author.

Tourism activities and management attend the national guidelines of the Brazilian Minister of Tourism, which builds public policies in a regional scale context, grouping destinations according to their similarities (regionalizacao.turismo.gov.br). Therefore, all destinations in the Costa Verde e Mar tourism region have created their local tourism councils and a strong regional tourism council takes decisions based on the regional interests and contexts. The University of Itajaí Valley (Univali) contributes to the region development by offering academic qualification and research in several science fields, including tourism at the bachelor, master and doctorate levels. Many modal infrastructures underpin the development in the region, which includes the second most important Brazilian port, located in the border city of Itajaí, the international airport of Navegantes city (half an hour from BC), and the federal highway (BR-101) that links the entire Brazilian coast, reaching from Uruguay until the Northeast region. In addition, Beto Carrero World, the largest amusement park in Latin America (RUBIN, 2020), benefit the whole region by attracting more than one million people annually.

In the past two decades extreme weather and climate events have increased considerably in frequency and intensity, hitting the entire region. A particular

event occurred in November 2008 when many days of rain caused the largest flood ever registered in the area, isolating destinations, the airport, and shutting down the port of Itajaí. Unofficial estimates for this extreme rainfall event, and subsequent floods and landslides, projects about USD 350 million in losses (Marengo 2009). From the ten climate events listed in section 3.3.2.1 seven have impacted BC: sea level rise, storm surge, wind blast, temperature changes, intense rainfall, droughts, and hail.

4.2.2 Surveys and interviews

4.2.2.1 Survey design for visitor's perceptions

To measure and compare tourists' perceptions of climate change risk and values for destination's image to feed several indicators we applied two methods of data collection: *in-situ* and *ex-situ*. The first is extremely valuable to examine on-site visitors' experience, which can be influenced by the actual weather conditions at the time of the data gathering. The second has the potential to avoid such bias and depict visitors' responses based on destination's image, weather forecasts, and anticipated information on climatic conditions. Web surveys can be subject to a "non-observation error", since people that could be part of the sample may not have access to the web. However, they provide access to dispersed samples around the globe, and entail high privacy so that the respondent will be less likely to give responses based on social desirability (ATZORI; FYALL; MILLER, 2018). Applying both methods increase the study's accuracy and provide a better understanding of the real world. Additionally, both methods have been widely applied (separately) in the tourism and climate literature, aiming visitors' perceptions (ATZORI; FYALL; MILLER, 2018; CURNOCK et al., 2019; IGUALT JARA et al., 2019; RUTTY; SCOTT, 2015; WANG et al., 2019).

The Coastourd Index framework guides the formulation of questions, which present open-ended and closed-ended questions for both methods (see appendix B for questionnaires). However, questions differ between the two methods. Interviews are very suitable to gather qualitative information because the interviewer can interact to collect information as much as possible and

guarantee the understanding of questions, an advantage unavailable in the online survey. During the survey (*in-situ*), respondents were asked to provide their understanding about climate change and to qualify their potential behaviour under future potential scenarios such as “how and why climate change could affect your trips?”. The use of “yes”, “no”, or “maybe” questions complemented the questionnaire to elicit tourists’ decisions and preferences. In the online survey, respondents had to indicate their level of agreement/disagreement on a 5-point scale (1 = strongly disagree; 5 = strongly agree) to a set of questions. Similarly, respondents (who usually travel) had to provide ratings of their desirability to visit 13 national- and internationally recognised beach destinations (1 = extremely undesirable; 7 = extremely desirable). The score was then parameterised to fit the Coastourd Index 0-1 scale.

Climate change threat awareness and perceptions were elicited by asking respondents to select one statement from four options that best reflected their behaviour under potential climate-related scenarios: (1) “Travel and take the risk”, (2) “Postpone the trip, keeping the same destination”, (3) “Change destination, keeping the same date”, and (4) “Cancel the trip completely”. To obtain climate condition preferences for temperature, rainfall, and wind speed, respondents were asked to choose their “ideal”, “tolerable”, and “unacceptable” condition when staying at the beach. Finally, respondents answered questions to identify their likelihood to financially contribute for beach destination’s adaptability in general and specifically for BC.

4.2.2.2 Data collection, sample, and analysis

The first (*in-situ*) survey occurred in BC using face-to-face interviews during the carnival week in February 2020 between 9:00 and 21:00. The survey instrument was first pilot-tested with a sample composed of 25 random people from the destination. The pilot test aimed to adjust the questions and the questionnaire structure regarding their clarity and understandability. The sample of 396 interviewees were undertaken by the principal investigator and a second trained researcher (Figure 4.4) with consenting tourists at the main beaches and tourist

attractions using the off-line application Coletum (coletum.com). For the purposes of this study tourists are defined broadly as non-residents of BC and its adjacent areas. Surveying was continuous whereby as soon as one survey was fully completed. Questionnaires whose data were incomplete because of tourist refuse (~5%) were discarded immediately to avoid missing values. When there was more than one visitor present in a group, the most interactive respondent over 18 years old was selected. By that time, Covid-19 had not been detected in Brazil and the summer season was running normally.

Figure 4.4 – Tourists' data collection (Feb/2020).

The second (*ex-situ*) survey was conducted online over the months of Jun to Aug 2021. The online questionnaire was built through Survey Monkey, and it was subsequently tested with a small sample of 11 respondents who were Portuguese, English, and Spanish speakers. After adjustments, the self-administered questionnaire was distributed through a link in the researcher's social network (WhatsApp, Facebook groups, Instagram, and e-mails), and it was available in the three languages: Portuguese, English, and Spanish. Initial screening questions were conducted to guarantee that respondents were non-residents of BC and adjacent areas, and that they were aged over 18. Only one answer per IP (internet protocol) was allowed, so that the results reflect a wider and more heterogeneous sample. The targeted population for the study was

composed of tourists who had previously visited a beach/coastal destination. At the end of the data collection period, a total of 415 responses in Portuguese (382), English (20), and Spanish (13) were collected. However, respectively 211, 12, and 7 surveys were completed and therefore used for the analysis, totalling 230 respondents.

All participants in this study were selected through a nonprobability sampling method. Specifically, an accidental or convenience sampling technique was employed, a type of sampling that is based on the availability of subjects to participate in the study. Respondents participated voluntarily, and the instrument was designed to do no harm to respondents who volunteered to participate in the study. Confidentiality and anonymity were secured to protect respondents' identity. The study, which involves human participants, was reviewed and approved by the Research Ethics Committee (CEP) under registration number 28504719.1.0000.5503 placed at the Vale do Paraíba University (UNIVAP), on behalf of the Brazilian Research Ethics Committee (CONEP). All respondents gave informed consent to participate in the voluntary survey. Both descriptive and inferential analyses were conducted using MS Excel and SPSS (v.28) software for providing means and comparing the distribution of rating scores for a range of 5 or 7-point scaled response questions as well as ideal climate condition preferences, as described above.

4.2.2.3 Stakeholders' interviews

Several indicators in the Coastourd Index are scored using information provided by stakeholders, here, represented by the local institutions (governmental and non-governmental) and the tourism industry of BC. For this study, the term 'tourism industry' refers to tourism-related businesses comprising hoteliers, food & beverage enterprises (cafes, restaurants), entertainment locations for tourists (clubs, bars), tour operators (travel agencies, dive- boat- transfer operators), and other business sportive operators (e.g., stand-up paddling, kayaking, surfing, paragliding, kitesurf, helicopter).

Restrictions posed by Covid-19 prevented to collect data on-site so that interviews were conducted online from July to August 2021 according to stakeholders' availability. However, such a restriction limited to gather a larger sample of the tourism industry because most enterprises were too involved in activities to cope with the crises on their business. Therefore, a total of 14 questionnaires containing open-ended and closed-ended questions were applied to the institutions (seven) and to the tourism industry (seven) (see Appendix B for questionnaires). Participants were selected based on their role at destination, their position and affiliation, for example, professors, directors, managers, and experts from institutions.

Similar to the tourist survey, stakeholders had to indicate their level of agreement/disagreement on a 5-point scale (1 = strongly disagree; 5 = strongly agree) to a set of questions. They were also asked to provide details on how extreme natural events could impact the destination, therefore, their businesses. To identify the main player institutions in the destination, each stakeholder was asked to provide the three main important institutions for their business or activity. Descriptive and inferential analyses were conducted using MS Excel. Network analysis would be suitable for detecting relevant institutions by measuring density of ties and centrality (see LUTHE; WYSS, 2016). However, a larger sample is needed to run such a technique.

4.3 Visitors' perceptions of climate risk

In the context of climate change, risks can arise from potential impacts of climate change on lives, livelihoods, health and wellbeing, economic, social and cultural assets and investments, infrastructure, services (including ecosystem services), and ecosystems and species (REISINGER et al., 2020). The human responses to cope with such potential impacts determine the extent to which communities, cities, places, or tourist destinations will be affected (ADGER et al., 2005). The climate risk perception plays a very important component on visitors' destination choice, with significant implications on demand patterns and tourist behaviour (ATZORI; FYALL; MILLER, 2018; SCOTT; GÖSSLING; HALL, 2012). Therefore, it is essential to understand tourist perceptions and reactions

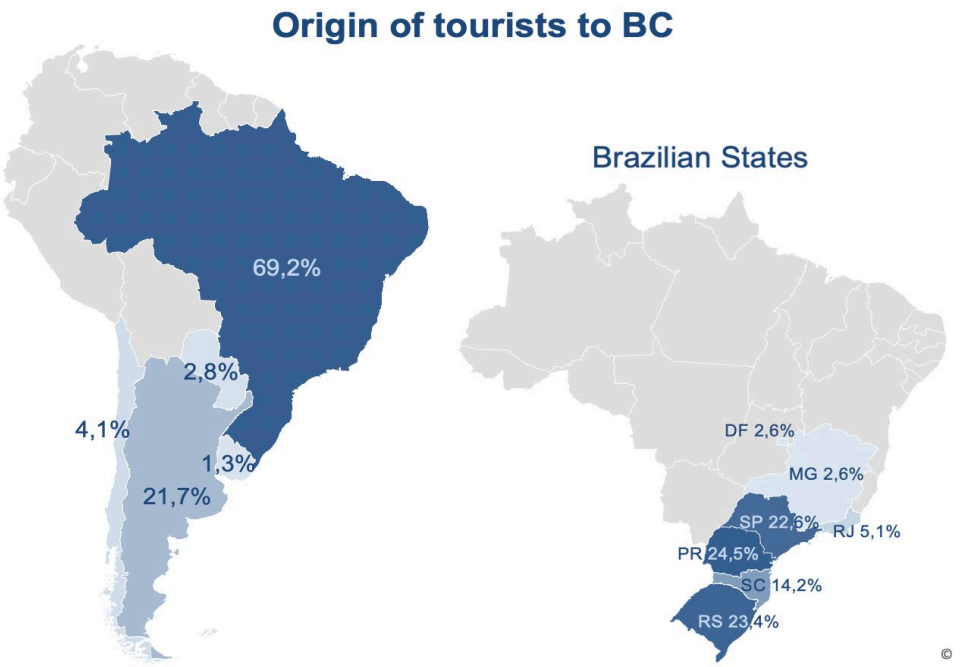
to the impacts of climate change to anticipate potential changes in tourism markets that might shift geographic and seasonal tourism demand that impacts destinations (ATZORI et al., 2019; GÖSSLING et al., 2012). This section presents the first study ever conducted in the Brazilian context to understand tourists' perceptions and their potential behaviour under a climate change scenario.

4.3.1 Demographics/profile of tourists/respondents

The demographic profile of respondents from the *in-situ* (*ex-situ*) survey showed a balanced (imbalanced) sample in terms of gender, where female represented 53% (69%) of the sample. Education level differed considerably between the two samples. Most interviewees (*in-situ*) finished high school (44.7%) and undergraduate (44.4%), whereas a fairly higher education level was found in respondents from (online) *ex-situ* survey, since 68.4% completed postgraduation (28.1%), masters (21.9%), and doctorate degrees (18.4%). As a reflection, their income also diverged. On-site respondents were from middle toward lower social classes (32% D, 28% C, and 23% E), while in the online survey 84% belonged to middle toward higher classes (34% C, 26% B, and 24% D). There is also an asymmetry in both samples when comparing age distribution. On-site tourists aged toward the younger end (29% 31-40, 27% 25-30, and 15% 18-24) but in the online survey respondents aged toward the older end (31% 31-40, 20% 41-50, and 19% 51-60).

In terms of origin, 69.2% of tourists interviewed in BC (Figure 4.5) were Brazilians coming from the bordering states of PR - Paraná, accounting for 24% of nationals (or 17% of the total respondents), and RS - Rio Grande do Sul, responding for 23% (16%) as well as the state of SP - São Paulo contributing with more 23% (15%). Internationally, Argentineans summed 70% of the foreigners (22% of the total) followed by Chileans 15% (5%) and Paraguayans 9% (3%) as shown in Figure 4.5. In the online survey, most respondents were Brazilians (94%) who were residing in Brazil (91%) in the states of SP (30.4%), MG - Minas Gerais (19.1%), TO - Tocantins (12.6%), RJ - Rio de Janeiro (5.2%), and DF - Distrito Federal (4.8%).

Figure 4.5 – The origin of tourists to BC.



4.3.2 Characteristics of visits (online survey)

The vast majority of respondents travelled mainly for leisure purposes (74.3%) and for visiting friends and relatives (11.7%). In more than half of the cases, the last Brazilian beach destination visited was in the states of SP (26.6%), RJ (21.1%), and BA – Bahia (10%) and occurred in the previous two years of 2020 (24%) and 2021(46%), as Table 4.2 shows. The three main activities enjoyed by the majority of respondents included relaxing and sunbathing on the beach (91.7%), swimming (84.7%), and walking on the beach (83%), followed by activities entailing trekking, wildlife observation, and cycling (Table 4.3). These findings are the same ones when comparing the three main activities tourists engage in in Florida, where Atzori; Fyall; Miller (2018) found that respondents (n=432) usually enjoy walking (91.4%), beach relaxation/sunbathing (87.3%), and swimming (74.3%). The only (and slight) difference is the order of preference, since walking is the first between North Americans and the third between Brazilians, who also prefer swimming more than the North Americans.

Table 4.2 – Destination visits characteristics.

Main visit purpose			States visited			Year of last trip		
	Frequency	**(%)**		**Frequency**	**(%)**		**Frequency**	**(%)**
Leisure/holidays	171	74.3	SP	58	26.6	2021	101	46.3
Visit friends and relatives	27	11.7	RJ	46	21.1	2020	54	24.8
Events (conference/congress)	5	2,2	BA	22	10	2019	36	16.5
Business/professional	3	1.4	SC	18	8.2	Others	27	12.4
Education	1	0.4	PE	17	7.8			
Other	11	4.8	AL	11	5			
Never visited a Brazilian beach destination	12	5.2	CE	10	4.6			
			Others	36	16.4			
Total	230	100	Total	218	100	Total	218	100

Table 4.3 – Main activities tourists engage in when visiting a beach destination.

Activities (n=230)	Frequency	(%)
Beach relaxation/ sunbathing	211	91.7
Swimming	196	84.7
Walking/running (on the beach)	191	83.0
Trekking (forest)	65	28.2
Wildlife observation	62	26.9
Cycling	31	13.5
Snorkelling	30	13.0
Scuba diving	16	6.9
Surfing/wind surfing	8	3.5
Fishing	8	3.5
Jet ski	2	0.9
Others	18	7.8

4.3.3 Most desired destinations by tourists (online survey)

When asked to classify their desirability to visit or revisit 13 destinations (scaling from extremely undesirable to extremely desirable), respondents placed BC in the 10th position (Table 4.4). However, the score (5.02) is higher than national- and internationally recognised destinations such as Rio de Janeiro (5.00) and Miami in USA (4.87). Far away, Fernando de Noronha Island is the most desirable destination (6.26), and the least desirable is Guarujá (4.37). Moreover, 47.3% of respondents agree (30.8%) and strongly agree (16.5%) with the statement “I have a very positive image of BC” (M=3.45, SD=0.49, 0-1 scale=0.690). Such image can be confirmed by examining the on-site survey conducted by Fecomercio (2020) for the 2019 summer, where 67.3% of visitors

had been visiting the destination for the fifth time or more (0-1 scale=0.810). Also, when conducting the *in-situ* survey, few tourists from Argentina and Chile stated that they had been visiting BC since childhood, which supports the relatively strong image of the destination.

Table 4.4 – Destinations' desirability ranking.

Destination	Mean Value	SD Value	Z-score	0-1 Scale
Fernando de Noronha	6.26	1.33	2.39	.894
Cancun	5.64	.81	.94	.806
Punta Cana	5.48	.71	.56	.783
Sydney	5.45	.72	.49	.779
San Andrés	5.36	.67	.27	.765
Fortaleza	5.20	.69	-.09	.743
Recife	5.20	.64	-.10	.743
Punta del Este	5.19	.63	-.11	.742
Salvador	5.10	.67	-.33	.729
Balneário Camboriú	5.02	.68	-.53	.717
Rio de Janeiro	5.00	.62	-.58	.714
Miami	4.87	.51	-.88	.696
Guarujá	4.37	.63	-2.05	.625

4.3.4 Visitation intentions under climate condition and climate-related impact scenarios (online survey)

After assessing respondents' desirability, questions to investigate visitation intentions followed a climate condition scenario in coastal destinations were analysed. As depicted in Table 4.5, responses vary depending on what type of impact has been considered. Respondents were asked what their likely reaction would be if, in the week before their departure to a 5-day holiday trip, they find out a risk (projection) of bad climate condition at their beach destination. They had to choose either they would "travel and take the risk", "postpone the trip but keeping same destination", "choose a different destination, keeping the same dates", or "cancel the trip completely".

Rainfall was least perceived by tourists as a climate risk comparing to storms. For the prediction scenario of rainfall occurrence for "some days" (7 days), 74.8% (41.3%) of respondents would take the risk and keep their trip. The

number reduce to as low as 37.4% (13.9%) if storms are predicted for some of the days (7 days), and other 35.2% (21.7%) would choose a different destination under storms (rainfall) conditions for the coming 7 days. Tourists are also concerned about storm surges, since 34.3% (38.3%) of respondents would postpone their 5-day trip under a storm surge prediction for some of the days (7 days), whereas 28.3% (33.5%) would travel to a different destination.

Table 4.5 – Visitation intentions under different climate condition scenarios.

Climate condition (n=230)	Travel and take the risk (%)	Postpone the trip / same destination (%)	Change destination / same date (%)	Cancel the trip completely (%)
hurricane	1.3	24.3	29.1	44.8
drought (water scarcity)	11.3	24.8	42.5	21.3
severe storms for the next 7 days	13.9	36.5	35.2	14.3
storm surge for the next 7 days	20	38.3	33.5	8.3
hail	30.4	32.2	25.2	12.2
storm surge in some days	29.6	34.3	28.3	7.8
severe storms in some days	37.4	35.7	20.9	6.1
raining forecast for the next 7 days	41.3	33.5	21.7	3.5
raining forecast for some days	74.8	14.3	9.1	1.7

Hail has lesser impact on visitors' perception of risk than the more frequent events. A third of respondents (30.4%) would take the risk and keep their travelling plans under a hail prediction scenario. However, 32.2% would postpone their 5-day trip and 25.2% would rather prefer visiting a different destination. Overall, hurricanes and droughts are the climate events most sensitively perceived by tourists as a risk. The great majority of respondents (44.8%) would prefer to cancel their 5-day trip completely and 29.1% are willing to travel to a different place under the imminence of hurricane at the destination. When droughts are the case, 42.6% choose another destination and 24.8% prefer to postpone the trip, whereas 21.3% would cancel it completely.

All these findings emphasise the tourists' highly sensitivity to extreme events such as storms, storm surges, hurricanes, and droughts. From the results, we

can also identify that the tourists are less likely to accept prolonged climate conditions of some events, which implies that climate extremes increase (e.g., frequency and intensity) will negatively impact coastal destinations. Rainfall is the most acceptable climate condition, even if prolonged during tourists stay. Findings from the in-situ survey (*n*=396) indicated that, on average, 54.3% of interviewees would stay in BC even under a rainfall condition for their whole stay of 4-7 days (59,1%) or 8-15 days (51.9%). Conversely, storm surges are not much appreciated given that 58.3% of tourists from the same in-situ survey demonstrated no interest in watching this phenomenon at the beach, whereas 34.5% would do it from a safe place.

Atzori; Fyall; Miller (2018) stress that prolonged rainfall, changes in extremes, and other elements such as disease risk affect comfort experienced by tourists, consequently they influence leisure travellers' destination choice. Then, disregarding destinations' climate projections for extreme events, destinations must prepare to cope with and adapt to the challenges posed by climate change to neutralize impacts on tourism flow. This suggests that climate change should be considered in tourism policies and planning in order to develop strategies for increasing resilience to floods, beach erosion, diseases, biodiversity loss, wind blast and other climate-related direct and indirect impacts portrayed in Table 3.3.

In an attempt to examine the relative importance that tourists assign to different biophysical and climate-related impacts (Table 4.6), in this set of questions respondents were asked about their likelihood to visit destinations that are being affected by some climate-related events. For beach erosion, 41.7% stated they would keep their trip under a beach reduction scenario of 30% or lower. However, 56.5% (61.3%) would change the destination in case of beach disappearance of up to 50% (≥ 70%), and 22.1% would cancel their trip completely in the face of ≥70% on beach reduction (the most avoidable scenario). The second most unpleasant scenario would be the increase of tropical diseases, since 79.5% would shift their destination (48.2%) or would cancel their trip completely (31.3%). In the condition that inundations caused by

rainfalls or storm surges strike the destination, 58.2% of respondents would seek for a different region to visit at the same planned dates. These findings are in line with those by Atzori; Fyall; Miller (2018), who found that 76.6% of tourists in US would visit another destination if tropical diseases become more widespread and 74.1% (56.7%) would do the same in case of beaches largely disappear (streets frequently flooded).

Table 4.6 – Visitation intentions under different climate-related impacts.

Climate-related impacts (n=230)	Travel, no problem (%)	Postpone the trip / same destination (%)	Change destination / same date (%)	Cancel the trip completely (%)
Beaches disappear ≥ 70%	7.8	8.7	61.3	22.1
Tropical diseases more frequent	10.4	10	48.2	31.3
Streets frequently flooded as a result of rain / storm surge	3.5	19.6	58.2	18.7
Beaches disappear up to 50%	18.2	12.1	56.5	13
Marine biodiversity largely disappears	26.5	9.1	48.7	15.6
Corals severely bleach	29.5	8.2	44.3	17.8
Increase of storms throughout the year	24.3	21.3	42.6	11.7
Beaches disappear up to 30%	41.7	13.9	36.9	7.4

In a scenario of marine biodiversity disappearance (severe coral bleaching) 48.7% (44.3%) of respondents would seek for another destination to visit, and 26.5% (29.5%) would travel without any problem. However, Table 4.3 shows that only 26.9% acknowledged that usually engage in wildlife observation. The *in-situ* survey also contributes to this contrast, since interviewees in BC considered “water transparency” (64%), “weather (sunny)” (60%), and “water and air temperature” (53%) the three most important criteria when choosing a beach. Marine biodiversity ranked the last position (13%) on tourist’s concern, behind “sand quality (whiteness/fineness)” (28%), “sand strip (short/long)” (36%), and “sea softness (calm waves)” (41%). Such a contradiction confirms previous studies by Atzori; Fyall; Miller (2018) for Florida in USA, where more than 46% of respondents stated they would choose a different destination in a

scenario in which “corals severely bleach” and “marine wildlife largely disappears” but assigned relatively lower importance to biodiversity attributes as factors for choosing a destination.

Respondents perceive storms slightly different when comparing to the preceding set of questions. Here, they were more sensitive to “increase of storms throughout the year” than to “severe storm in some days” in the previous one. Here (there), 42.6% (20.9%) would change their destination, another 11.7% (6.1%) prefer to cancel the trip completely, and 24.3% (37.4%) sees no problem in visiting the place under such a scenario. This is an intriguing result because visitors seem to be less sensitive to more accurate climate forecast, that provide more certainties for their coming planned trip, than to extreme climate events along the year. It intrigues because severe storms predicted for the visit period appear riskier than the vague information of an increase of storms distributed throughout the year (without a precise season). Exclusion of uncertainty might be a possible explanation, since uncertainty lowers public expectations, decreases consumer confidence, and fosters pessimism, according to a study by Van Dalen; De Vreese; Albaek (2017) using economic news.

4.3.5 Preferences for weather and climate conditions when visiting a beach/coastal destination (online survey)

To determine the range of optimal climate, respondents were asked to assess their preferences for weather and climate conditions when visiting a beach/coastal destination. Three different weather attributes were examined – air temperature, rain and wind – and the relative results report the thresholds within the continuum from “ideal” to “unacceptable”. Beachgoers considered an average of 29.4 °C (SD=3.17) as the ideal air temperature condition when visiting a beach, 33.6 °C as tolerably hot (SD=4.15), and 38.2 °C (SD=4.95) as unacceptable. Earlier studies (*ex-situ*) conducted by Scott; Gossling; De Freitas (2008) found that a temperature of 27 °C was ideal for a beach vacation. Atzori; Fyall; Miller (2018) found a slight lower result for Florida beach users, respectively 27.8 (ideal), 32.1 (tolerable), and 36.7 °C (unacceptable) for the

same questions. Another similar study by Rutty; Scott (2015) conducted in the Caribbean interviewed 472 beach tourists from temperate regions (75% from UK, northern USA, Canada, Germany) and showed that 30 °C was the most acceptable air temperature, which ranged from 28 to 32 °C. Hence, the three studies show very close results except for North Americans, who seem to prefer a bit lower temperature (~2 °C) than other nationalities.

For daily rain conditions, 59% of respondents indicated that “no rain” is the ideal weather when visiting a beach destination, but on average they accepted less than an hour (M=0.63, SD=0.91) as the ideal condition for rain. Between 2 and 3 h (M=2.29, SD=1.37) were considered tolerable, while more than 6 h (M=6.36, SD=2.07) were perceived as unacceptable. Results for wind condition showed that 75% of beachgoers elected a light breeze (1-11 km/h) as the ideal wind condition at the beach (M=11.73, SD=6.78), while 69% considered a moderate wind (12-27 km/h) as tolerable (M=26.61, SD=12.12). However, a very dispersed result was noticed for the unacceptable wind condition, where 42% selected strong wind (28-48 km/h), 29% very strong wind (49-87 km/h), and 23% storms (88-117 km/h) (M=73.16, SD=31.47).

For these attributes, Atzori; Fyall; Miller (2018) identified respectively similar, minor, and great difference results for ideal (M=0.078), tolerable (M=1.50), and unacceptable (M=3.73) daily rain conditions for beach/coastal vacation in Florida. The greater difference regards the “unacceptable condition”, in which North Americans (more than 3 h) appear to be more sensitive to rain than Brazilians (more than 6 h). Similar patterns are notorious for wind conditions. North Americans perceive a moderate wind as the ideal (M=12.93) and tolerable (M=22.03) conditions but they are more sensitive to the unacceptable (M=35.39) wind condition than Brazilians (M=73.16). Gómez-Martín (2006) interviewed tourists in Catalonia (Spain) during summer and found a strong demand for sunshine. Tourists expressed that less than 1 h of rain was acceptable but more than 3 h of rain would totally ruin their experience. Scott et al. (2008) found that tourists in Canada, New Zealand, and Sweden identified a

light breeze as ideal for a beach vacation, with results varying based on the respondents' nationality.

4.3.6 Financial contribution for climate change adaptation programmes (online survey)

To investigate the likelihood of beachgoers to financially contribute to climate change adaptation measures, respondents were asked the amount of money they would be willing to pay per day/person as a tourism adaptation tax for any beach destination and specifically for BC. On average, 90% of Brazilians (n=211) would pay BRL 12.68 (USD 2.28, 2021 rate) to help beach destinations in general. This amount would decrease to as low as BRL 9.74 (USD 1,75) when BC was pointed out as the targeted destination. International respondents (n=19) would be happy to contribute with USD 7.57 for adaptation strategies, disregarding the destination on focus. Immediately after these questions, respondents were asked to briefly justify their answers, which were classified into six main dimensions.

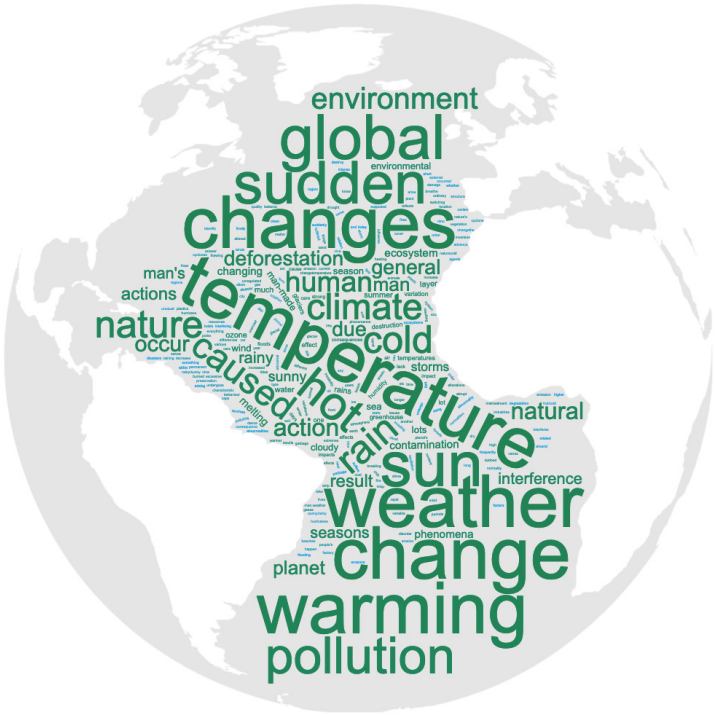
The first category related to a sentiment of "Helping the environment, the climate change issue". This group represented 32.2% of respondents and recognised the importance of places to adapt, its contribution to press the environment (intensifying the problem), and that adaptation costs money: "I find climate change adaptation important and understand that it costs money." Other respondents stated that "It is very important to take care of the environment" or even to "maintain the beach for future visits". The second largest group (22.6%) provided "budget" reasons to justify their contribution. The greater concern was about the trip costs increase such as "Any more [money] may be a deterrent to making many beach trips", "I think it is an accessible and fair amount", or "When travelling with family, a higher amount can compromise the trip". The third group (14.8%) showed elements of "negative emotional content" about BC. Many respondents stated, "I have no intensions to visit it", "I dislike beaches with so many buildings", or "It is a city that disrespected the environment by allowing lots of high buildings".

The fourth group (12.6%) was formed by respondents who indicated “public-private obligation” to fund adaptation measures since they benefit from the great tourism flow, “I believe the local government should take care of this because the city’s revenue from tourism is high”, “We Brazilians already pay many taxes”, or “There is a big speculation in the real estate market, then the city has enough money to allocate in such actions”. Another and fifth group (4.3%) manifested a “positive emotional sentiment” for BC. Answers such as “BC is a very desirable destination [to me]”, “[Because of the] tourist attractiveness”, or “Beautiful city, well maintained” came up in the responses. Finally, the last group (3%) was classified in a category of “lack of trust” because it has “Little trust in the government”, “…there’s a great chance of this contribution be used to contribute to corruption…”, or “Correct investments are needed, not political robberies”. Around 10% of responses were unrelated to the topic or unsated such as “Not sure, just guessing”, or “It is worth to pay for clean and patrolled beaches”.

4.3.7 Tourist understanding about climate change and their potential behaviour (*in-situ* survey)

To assess tourist understanding about climate change and to investigate their motives for any potential behaviour, respondents answered four questions, only the first one was closed-ended. Firstly, they were asked ‘do you know what climate change is?’. The great majority, 78.3%, indicated ‘yes’, while 20.7% chose ‘I have heard about it’, and the remaining 1% did not know. Secondly, they had to qualify what climate change was in their opinion. Most tourists cited ‘sudden changes in the weather’ to express an abrupt variation in the temperature, from hot to cold and vice-versa. This was highly associated with sunny and rainy days and commonly linked to the global warming. Tourists also associated global warming as a consequence of human/man’s actions, including pollution that negatively impact the nature/natural environment. Figure 4.6 provide a visualisation of most cited words that tourists used to explain their understanding about climate change.

Figure 4.6 – Most cited words to explain the climate change phenomenon.



The size of words represents the relative frequency of responses. Words occurring fewer than 12 times are omitted.

A third question examined whether, how and why climate change could affect tourists' destination choices. Figure 4.7 shows the main words cited. Three-quarters (76%) of respondents agreed by answering 'yes', the variations in climate could impact their choice. The most common explanation was that 'the weather in the destination must be consistent with the temperature of the season'. In other words, when travelling for a beach destination during summer, tourists expect sunny days and hot temperatures. Many respondents indicated they wouldn't visit the beach if it was raining or cold, and a few already switched destinations for these reasons. Some respondents usually made their destination choice based on the weather: 'I always look at the weather to decide the destination'. Moreover, tourists have specified their fear of possible climate events occurrence such as floods: 'I would avoid visiting places with a risk of flooding'.

On the other side, 22.5% of tourists stated that climate change would have 'no' impact on their destination's choice. When analysing their reasons, almost half in this group (45%) demonstrated an emotional attachment to BC: 'I always like

to come to BC, regardless the weather/climate'; 'I have been coming to BC for over 20 years'; 'I love BC and I have been coming to this destination for years'. A few respondents highlighted the importance to feel safe in the destination: 'I like coming to BC. It's quiet and safe'; 'I always come to BC because it's safe and calm'. Despite the emotional motivations, tourists have also provided rational reasons such as: 'Once I decide my destination, I only change the day tours in order to enjoy the place'; 'Once the destination is decided, I look for the best time to visit it'.

Figure 4.7 – Most cited words to explain how climate change influence tourists' destination choice.

The size of words represents the relative frequency of responses. Words occurring fewer than 12 times are omitted.

A final question investigated the tourists' potential behaviour based on their perceptions about climate change. Figure 4.8 shows most cited words by tourists when asked if and how/why climate change could affect their annual period of travelling. More than half (51.5%) affirmed 'yes' by explaining they would change their annual travel period to visit the destination previously chosen: 'I would change the period of visit for a sunny season'; 'I would choose

the best time of the year to visit my desired destination'; 'I would change the dates but not the destination'.

Figure 4.8 – Most cited words to explain how climate change affects tourists' annual period of travelling.

The size of words represents the relative frequency of responses. Words occurring fewer than 12 times are omitted.

Amongst the group who indicated 'no' interference on their annual travelling plans (46.7%), the main reasons were associated with work and/or school holiday, for those who had children. Majority of them (20.7%) clearly specified they would change destination to travel during their available dates: 'I always go on a trip at the same time, I just change the destination based on the weather [forecast]'; 'I would change the destination to travel during my holidays. A lower number of tourists (16.4%) did not detail if they would travel to the same destination: 'I always travel during the holidays regardless the temperature', 'I have no flexibility in my holidays'. A third cluster of respondents (8.1%), composed of both 'yes' and 'no' groups, demonstrated a relatively strong attachment to BC: 'No, because I would come to BC even if it was raining'; 'Yes, because I like to come to this beach. BC is the best place for holidays: quiet and safe'.

4.4 Stakeholders' perceptions about tourism and climate change in Balneário Camboriú

Stakeholders' interviews provide valuable information to understand contextualised factors that might influence vulnerability and resilience in the perspective of climate change. In this regard, first subsection presents the findings for each of the two stakeholders' categories: tourism industry and institutions (see methods). The list of stakeholders included one representative of each of the following local government institutions responsible for (1) tourism, (2) environment, and (3) civil defence. Additionally, three interviewees were from two universities, one from the Tourism Intermunicipal Consortium, which represents the nine municipalities of Costa Verde & Mar region, three from hotels, two from travel agencies, and two from parks (entertainment), totalling 14 interviewees, seven from each category.

Tourism-related stakeholders in BC were asked to rate several assertions in a 5-point scale (1 = strongly disagree, 5 = strongly agree, where 5 represented the ideal condition). A second set of questions examined stakeholders' perceptions about the occurrence of eleven climate events in BC. They were asked to indicate which events had affected: their business (weight = 2), the destination (weight = 1), or had not occurred (weight = 0). Zero was the desired condition. In the first set of questions, few assertions were specifically applied for only one of the groups. A second subsection shows the results specifically for the tourism industry stakeholders for economic issues in relation to climate change. They were asked to answer several multiple-choice questions to evaluate their perception about climate interference on businesses and other related questions such as destinations' expertise.

4.4.1 Climate risk and governance perceptions

The results on stakeholders' perceptions about climate risk and governance are detailed in Table 4.7. Stakeholders highly agreed when asked about their (1) acknowledgment on potential harms of extreme natural events (ENEs) and (2) how such ENEs could impact their businesses or the destination. The tourism industry demonstrated a slight lower value (4.14 each assertion) than the

institutions (4.43 and 4.29, respectively). However, they could provide real examples on the types of impact. A respondent (hotel) indicated that 'the great flood of 2008 in Blumenau (SC) (70 km distant) had a big impact on BC's image, reducing dramatically the tourist flow'. Another stakeholder (travel agency) elucidated that 'on a day tour operationalisation to visit the cable car, wind blasts had isolated a group of 500 students uphill for couple of hours'.

Table 4.7 – Stakeholder's perceptions.

Item	Climate related assertions for: tourism industry (institutions)	Tourism Industry (n=7)		Institutions (n=7)		Average
		Mean Value	0-1 scale	Mean Value	0-1 scale	Mean Value
A	I (this institution) know(s) the potential harms of extreme natural events (ENEs)	4.14	.171	4.43	.114	4.29
B	I (this institution) know(s) how ENEs might impact: my business/company (the destination)	4.14	.171	4.29	.143	4.22
C	I have (this institution has) developed actions to check if staff is aware about the potential hazards of ENEs	3.29	.343	2.86	.429	3.08
D	This business/company (institution) has safety procedures in case of ENE occurrence	3.29	.343	2.71	.457	3.00
E	I usually receive or have received (through SMS, E-mail, etc.) early warning communication from official authorities about potential climate risk (e.g., flood, storms, storm surges)	3.43	.314	-	-	3.43
F	This institution issues or takes part in actions that issue early warning communication to the tourism industry about potential climate risk (e.g., flood, storms, hails, storm surges)	-	-	3.00	.400	3.00
G	This business/company (institution) has already implemented: safety procedures following an early warning communication (strategies to reduce the ENE risk in the tourism industry)	3.43	.314	2.86	.429	3.15
H	This business/company (institution) takes part at least annually in a group discussion or forums for exchanging experiences about disaster risk associated with ENEs, aiming to learn from past events either at this destination or other places	1.57	.686	3.43	.314	2.5
I	This business/company is integrated to an early warning system for ENEs	2.14	.571	-	-	2.14
J	The communication and early warning system are efficient at all phases: before, during, and after any disaster occurrence	-	-	4.00	.200	4.00
K	I really trust in doing business (working) in this destination. People are trustworthy, employers (institutions) respect agreements, and businesses (processes) run safely	4.00	.200	4.00	.200	4.00
L	When a conflict rises the local or subnational/national institutions act to fairly solve it	3.29	.343	4.00	.200	3.65
M	Conflicts are solved by democratic means and fair mechanisms that consider small and big groups	3.43	.314	3.86	.229	3.65

	equitably					
N	The decision-making processes are transparent. E.g., decisions about rules for opening a new small business or accessing public natural/artificial resources such as beaches, destination zoning, etc.	3.29	.343	4.17	.167	3.73
O	I feel represented in this destination. My ideas and suggestions for tourism are taken under consideration	3.86	.229	-	-	3.86
P	This institution considers ideas and suggestions of all tourism stakeholders in this destination	-	-	4.43	.114	4.43
Q	Enterprises and other organisations (government, legislative power, and other institutions) respect decisions taken	3.86	.229	3.86	.229	3.86
R	Business has a relative autonomy and flexibility to take decisions concerned specifically to my sector. Local and state government respect decisions. (E.g., spatial reorganisation for passenger's pick-up due to floods)	3.29	.343	-	-	3.29

These examples might explain the higher values assigned by the tourism industry on questions regarding respectively 'staff awareness' and 'safety procedures' (3.29 each) when comparing to the institutions (2.86 and 2.71, respectively). A comment provided by a stakeholder (travel agency) clarified that 'our staff are trained to execute plan A and plan B. In case of strong rainfall, for example, there are safety measures. It has occurred once during a day tour to visit some islands nearby. Good communication between bus drivers, tour guides, and whole staff, rescued a boat with 400 tourists from a risk of strong rainfall on course'. Such a statement reveals the importance for the tourism industry in receiving early warning communications about climate risk from official authorities (municipal, state, or federal level). This factor has been recognised by the tourism industry, which stated high agreement (3.43) on receiving communications through e-mails or SMS. On the other side, the institutions engaged a little bit lesser than the tourism industry, since their score was 3.00 for taking part in actions that issue early warning communication to the tourism industry about potential climate risks.

Likewise, the tourism industry scored higher (3.43) than the institutions (2.86) for implementation of safety procedures following an early warning communication. An explanation might be a survival effect, that is, the enterprises' lifetime depends on effective and efficient decisions taken in advance a potential problem. In this regard, 57.1% of the tourism industry

informed to have a strategic plan to cope with ENEs such as flood, rainfall, and droughts. The plan embraced built structures and training of staff. The other 48.9% admitted having no plan. A hotel manager described that the enterprise built an artesian well to cope with droughts in BC, an event that has been intensified in the current decade. Conversely, the tourism industry designated a low engagement (1.57) when questioned about its participation in groups or forums for exchanging experiences about disaster risk associated with ENEs, whereas the institutions scored as high as 3.43. As a reflection, there were a low (2.14) integration of businesses with an early warning system for ENEs, an opposite view presented by institutional stakeholders, who highly agreed with the assertion (4.00): 'the communication and early warning system are efficient at all phases before, during, and after any disaster occurrence'.

In the assertions related to governance, both groups had the same perception for trustworthiness since the high score (4.0 each group) implied that all stakeholders trust in doing business or working in BC. Yet, the tourism industry contrasted from the institutions on its perceptions about solving conflicts by local, subnational, or national organisations. It credited lesser trust (3.29) in fairly solutions than the institutions (4.00). Similar results were found for transparency in the decision-making processes, where the tourism industry perceptions were more sceptical (3.29) than perceptions of the institutions (4.17), and for conflict-solving by democratic and fair mechanisms, in which the agreement score was also lower between the tourism industry stakeholders (3.43) than amongst the institutional ones (3.86). Regarding this last issue, a stakeholder (tour operator) described that a conflict about double taxation involving the local government was fairly solved. However, another stakeholder (university) pointed out that construction companies played a great influence in the urban planning process, specially to approve the construction of higher buildings.

A more distinct result can be identified when analysing stakeholders' perceptions about their representation in the destination. For the tourism industry, its ideas and suggestions to develop the destination could improve. A

stakeholder (tour operator) explained that 'we had to create a local tour operator association to have voice on our interests. There are some requirements to access tourist resources that are not demanded from operators based in other states or even abroad. For example, we must hire a tour guide to offer a trip, but externals do not do it'. This justified the lower score (3.86) attributed for this assertion, while for the institutions (4.43) all tourism stakeholders' ideas and suggestions were considered. However, both groups equally agreed (3.86 each) that decisions taken in the destination are respected. A further question investigated the tourism industry's autonomy and flexibility for taking local decisions concerned specifically to the sector on focus. Interviewees agreed (3.29) that they had a medium autonomy and that local and state government usually respected decisions.

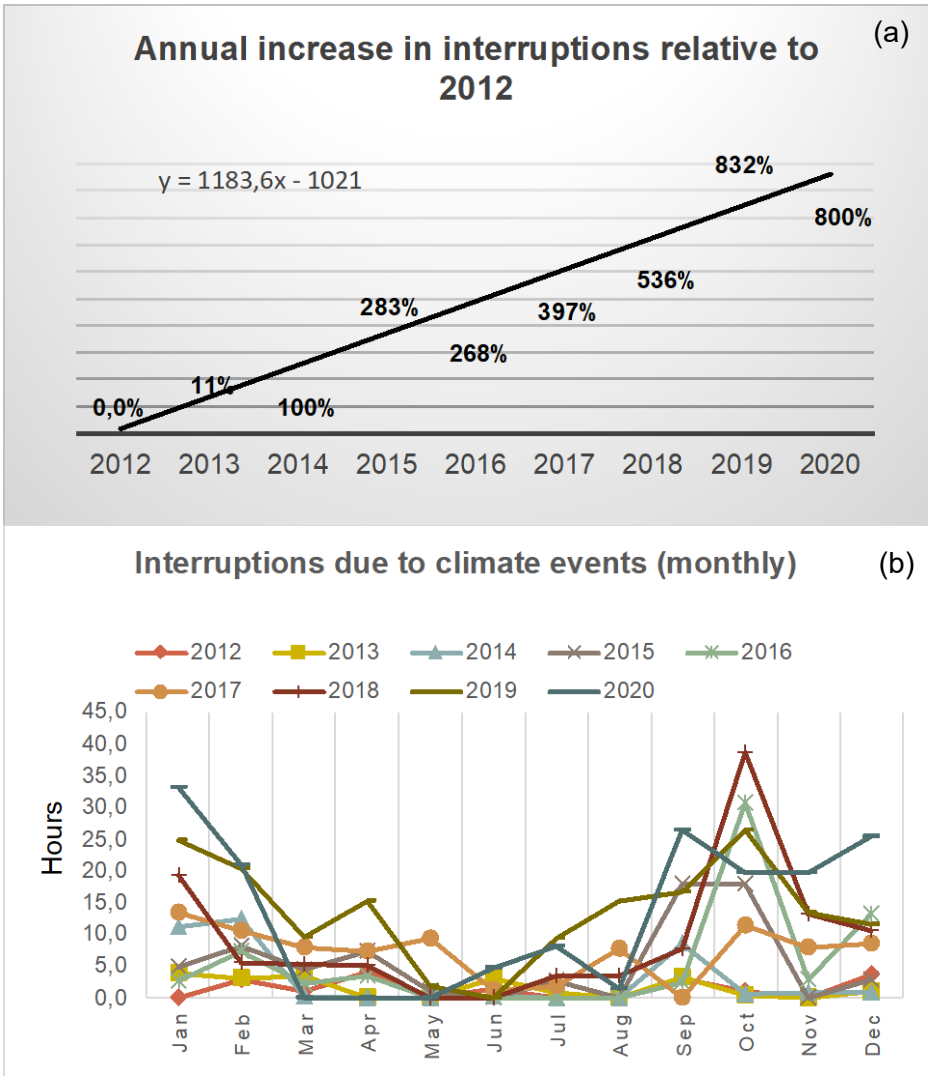
Table 4.8 – Stakeholders' perceptions about natural events occurrence.

Event	Tourism industry (n=7)	Institutions (n=7)	Average (n=14)
	0-1 scale	0-1 scale	0-1 scale
Changes in the rainfall/storm patterns: increase/decrease on frequency and/or intensity	.857	1.	.929
Water shortage (water stress)	.571	1.	.785
Wind blast increase	.857	.714	.785
Changes in climate (cold/heat waves increase)	.571	.857	.714
Sea level rise	.286	1.	.643
Storm surge increase	.500	.571	.536
Gradual changes in the temperature (colder/warmer or less cold/warm winters and summers)	.357	.714	.535
Hail - increase/decrease on frequency and/or intensity	.429	.571	.501
Changes on seawater temperature (colder/warmer)	.214	.143	.179
Hurricane	.071	.286	.178
Earthquake	0	0	0

In the second set of questions, stakeholders were asked to indicate which of the events listed in Table 4.8 had affected: their business, the destination, or had not occurred. The institutions only chose between last two options. For both groups, changes in rainfall patterns were the most noticed event in BC (0.929), followed by water shortage and wind blast increase, both rating 0.785. However, the tourism industry perceived water shortage as a lower risk (0.571) comparing to the institutions, in which 100% stressed the intensification of

droughts in BC. Lower difference was identified for wind blast increase, in which both have similar high perceptions of risk: tourism industry 0.857 and institutions 0.714. A stakeholder (park) whose attractions relies greatly on weather provided a report showing the amount of time the park had to interrupt its operations due to climatic conditions. In nine years of observation, interruptions have increased as high as 800%, forced mainly by events such as wind blast and lightning storms. As Figure 4.9 shows, most of this growth arose in Springs and Summer the highest season in BC. These episodes led the park to arrange forecast services to minimize risks, setting extra cost to the operation, therefore, for tourists.

Figure 4.9 – Annual (a) and monthly (b) increase of interruptions due to climatic conditions.



Source: own construction based on stakeholder's report.

Stakeholders also pointed out an increase in the cold/heat waves, the fourth most perceived event on average. However, the tourism industry had a higher perception of risk for wind blast than for cold/heat waves (0.571), possibly because wind blast had affected beaches, boat tours, cable car trips, and other activities directly related to their operations. Another stakeholder (travel agency) informed that a wind blast destroyed the structure where a football league would take place, forcing the company to cancel the event. Conversely, the institutions rated sea level rise (1) as a higher risk for the destination than wind blast and cold/heat waves, while the tourism industry perceived it as a low risk (0.286). Perchance they believed the beach nourishment, undergoing by the time of the survey, could tackle such a problem. When analysing storm surges, the two groups of stakeholders agreed on results. The tourism industry rated 0.500 and the institutions 0.571, but they greatly differed about the gradual changes in the seasonal temperatures, where this event were lesser perceived by tourism industry (0.357) than by institutions (0.714).

Changes in hails and seawater temperature had similar perceptions between two groups. The tourism industry was less sensitive to hails (0.429) than the institutions (0.571) but more sensitive to seawater temperature (0.214) than the second group (0.143). Note that a stakeholder (university) detailed that the whales' migration route has been altered because of the planktons' productivity reduction, an aspect influenced by factors such as changes in the seawater temperature. Hurricane and earthquake were both seen as a low risk of occurrence since stakeholders rated respectively 0.178 and zero on average.

4.4.2 Economic issues of the tourism industry and their climate perception

In the tourism industry's view, climate change has been causing a great impact on tourism businesses as well as on the destination as a whole. The agreement rate for this assertion (4.29, 0-1 scale = 0.858) was based on the same 5-point scale discussed in the previous subsection, but for this assertion only the desired condition is zero. When interrogated about easiness to hire skilled and qualified employees the tourism industry in BC averaged 3.00 (0-1 scale =

.400), but the institutions assigned a higher rate (4.43, 0-1 scale = 0.114). In a final assertion, enterprises indicated that when in time of constraints (such as Covid-19 crisis) they had a quite easy access to loans from either family (3.71, 0-1 scale = 0.257), friends, or banks.

Next question investigated the financial resilience of enterprises in time of crisis such as Covid-19. More than half (57.1%) admitted having resources to resist on business for 12 months and 28.6% even longer than 12 months. A few percentages (14.3%) specified up to 6 months. This resilience effect might be explained by years of knowledge accumulation and experience since 85.7% of enterprises lasts for ten years or more in the same business at the same destination. Thus, more experienced enterprises might deal better with financial crisis by accumulating capital for emergencies. However, only 28.6% of interviewees indicated a second source of income to compensate a scenario of 50% reduction in the revenues for a period of 12 months.

Moreover, interviewees indicated that 100% of owners were living and working in BC, another factor that determine resilience because locals usually develop emotional attachment to their place, therefore more reluctant to persist on business (BIGGS et al., 2015). However, when investigated about precaution actions in case of damage to enterprises' infrastructure or revenue loss, 71.4% of tourism industry acquired insurance to cover only physical damages, while the remaining 28.6% had no insurance arranged. When asked about international partnerships of any type, most of enterprises (71.4%) did not have any type of agreement or take part at any international association. A few percentages informed that were members of the International Association of Amusement Parks and Attractions, and the South American Union for Tourism Enterprises.

To identify the main central organisations that play important role for the destination, stakeholders were investigated to describe three organisations or institutions that were important for their businesses. The result showed a very dispersed connection. Only two institutions appeared more than once: the local organisation for tourism (Municipal Secretariat of Tourism) and the Destination

Marketing Organisation (Convention and Visitors Bureau – CVB), both had three citations each. Another fourteen organisations were mentioned once by interviewees. A larger sample would provide more elements to identify and analyse connections that could confirm and reveal other important stakeholders. However, as explained in the methods, tourism industry data collection was very impacted by Covid-19 restrictions.

4.5 Vulnerability and resilience of Balneário Camboriú to climate change – Results and discussions

This subsection presents the operationalisation and interpretation of the application of the Coastourd Index. Each of the nine subindices is composed by a maximum of nine indicators that explain the overall dimension under analysis (e.g., shocks & stressors; or biophysical environment). The theoretical assumptions that determine the destinations' VUL/RES for each variable are detailed in Table 3.4. Therefore, this subsection shows the score for each observed variable, the respective data source, and the implications for the destination under study. Several data are provided by the Brazilian Institute for Geography and Statistics (IBGE), which is the official institution to conduct household surveys and to collect data on demographic, social, economic, and housing variables such as gender, ethnicity, age, citizenship, and birthplace.

4.5.1 Shocks and stressors

The coastal region of SC has an important history of natural disasters due to extreme rainfall events. Floods and landslides are enhanced by local features such as topography and urbanization: the replacement of natural surface coverage causing more surface runoff and, hence, flooding. Barcellos et al. (2020) show that in Florianopolis, the most of the positive (negative) precipitation indices correspond to the years of the warm (cold) phase of the Pacific Decadal Oscillation (PDO), and with the highest frequency of El Niño (La Niña) events. They infer that rainfall totals in the months of greatest convective warming are decreasing in recent years due to the reduction in the number of rainy days or extreme rainfall. BC exhibit a high vulnerability (positive tendency, i1) to weather and climate extremes, showing a high score (0.602) in the

Coastourd Index scale for this subindex (Table 4.9). Seven out of the ten events listed in Table 3.3 that can affect coastal destinations suggest an increase in the frequency and intensity. However, one variable, sea surface temperature, has been excluded from the analysis due to lack of data and studies for the focused region of BC.

Table 4.9 – Shocks & Stressors subindex variable.

Observable variables	Source	Score
1. Climate & natural events tendency	See Appendix A1.1 for the scoring result of each event and data source	0.722
2. Attractions exposed	Local Tourism Planning (PMT, 2019); Interviews and local observation	0.481
	Total score (mean)	**0.602**

For sea level rise (SLR), a 5500-years study by Angulo et al. (1999) identifies past variations of 2.10 m to 0.20 m higher than the present for changes in the relative sea level in SC. However, the global mean sea level has increased constantly in the past century (1.3 mm yr $^{-1}$ on average for 1901-1990) and more intensively in the past two decades (3.7 mm yr^{-1} for 2006-2018) according to the latest IPCC AR6 report (IPCC, 2021, pp. 9–95). Regional projections for Imbituba, SC central coast, shows an increase of 0.59 (0.56 to 0.62) m in the lowest carbon emission scenario (SSP1-1.9) and 1.42 (0.85 to 1.99) m in the highest scenario (SSP5-8.5) for the year 2150 (1995-2014 baseline), an average rate of 0.41 mm yr^{-1} and 1.05 mm yr^{-1} respectively (IPCC, 2021). These projections are in line with studies by Da Silva; De Freitas; Dalazoana (2016), whose findings for SLR in Imbituba (Southern SC) show and increase tendency of 2.4 (± 0,2) mm yr^{-1} for the 2007-2014 period. Moreover, the Brazilian Panel on Climate Change report (PBMC, 2016) presents a positive tendency for SLR in SC of 2.11 mm yr^{-1} considering the 1950-2010 period. Therefore, these studies support the score 1 for SLR.

The PBMC (2016) report also shows an increase in the number of storm surges (28%), wind blasts (22%), hail (12%), and drought (25%) in SC for the 1980-2010 period, scoring 1 for each of these events. From these four categories, droughts are the most impactful. In fact, as compared to hydrological hazards (floods, flash floods, rainstorms, and landslides), droughts respond to 33% of

the total damages occurred by all natural hazards from 1995 to 2014 in SC (BRL 5.8 billion or USD 1.5 billion in 2019 rate), with great impact to food production (CEPED, 2016). Agriculture has been the most affected sector, accounting for 67% of the total damages in that period (*ibid*). Scott; Hall; Gossling (2019) consider 'food costs' as a variable in their index since climate change will reduce local food supply, increasing food prices for tourism due to transportation costs, consequently, increasing sensitivity to price volatility.

Hurricanes have never been registered in Brazil until Fall of 2004, when hurricane Catarina hit Southern Brazil causing more than USD 425 million in damages (MCTAGGART-COWAN et al., 2006). However, no study reports a probability of hurricane occurrence in Brazil, reason why this event scores zero. Likewise, Earthquakes are very unlikely to occur in Southern Brazil. The Brazilian Seismography Network identified few earthquakes (25) in SC since 1898, of which only four overpassed 4.0 in the Richter scale magnitude and the highest one (5.5) is still considered of small proportions, justifying the zero score for this event. Studies concerning annual and seasonal temperature trends suggest an increase in the air minimum temperatures (Tmin) and a relatively stability in the air maximum temperatures (Tmax) for the period of 1955-2008 in SC (MINUZZI, 2010) and 1960-2002 in Southern Brazil (MARENGO; CAMARGO, 2008). The mean Tmin have increased (warmer nights during winter) and the mean Tmax have risen slightly with warmer days in the winter and summer. If these patterns continue, they might benefit BC in the future since the in-situ survey results show that 73% of beachgoers (n=396) are likely to visit the beach in the winter under warmer temperatures.

Although a warmer winter will be still colder than the summer, Rutty; Scott (2015) observe that people adjust their thermal perceptions according to their comfort expectations, so they expect higher temperatures in the summer season rather than in the winter. In addition, the three most popular activities that people engage in when visiting the beach are sunbathing (91%), swimming (84%), and walking/running (83%) (respondents could choose more than one alternative, n=230). The later one would probably be the least likely to do in the

winter. On the other hand, increase in extreme temperatures might have a negative impact for the destination. Steil et al. (2020) show a slight increase in the frequency and intensity of cold- and heat waves (Cw/Hw) for the 1982-2017 period in the central coastal area of SC, which includes BC. Bitencourt et al. (2018) present similar findings for Southern Brazil considering the 1961-2016 period. The studies state that Cw (Hw) happen when temperatures are below (above) the 10th percentile (90th percentile) of daily minimum (maximum) temperatures for at least five consecutive days (STEIL et al., 2020) or three consecutive days (BITENCOURT et al., 2020).

Extreme high temperatures and more frequent Hw have potential to negatively impact the tourist flow in BC since they happen in the highest and transition seasons (summer and spring), reaching temperatures of up to 5 °C above the mean maximum temperature (30-32 °C) for summer (STEIL et al., 2020). This is in accordance with Scott; Gossiling; Hall (2012), who highlight that climate conditions might degrade the peak summer tourism season in many subtropical and tropical destinations. To support this argument, results presented in section 4.3.5 illustrate that beachgoers considered temperatures of ~38 ºC unacceptable when visiting a beach destination. Therefore, accepting that extreme high temperatures can negatively affect and that warmer winters can benefit BC, a 0.500 score is given to this event.

Rainfall patterns are crucial for any destination. They can trigger natural disasters such as floods, landslides, or droughts, impacting tourism development since tourists avoid rainy season when visiting beach destinations (DA SILVA SANTOS; MARENGO, 2020; ROSSELLÓ; BECKEN; SANTANA-GALLEGO, 2020). Gonçalves and Back (2018) note a relatively stability in the Precipitation Concentration Index (PCI) for the three Southern Brazilian states in the 1976-2015 period. The PCI evaluates the precipitation distribution along the year and season, and the results for Santa Catarina shows positive tendency (increase) in the precipitation frequency for only 12% (17,3%) of the meteorological stations in the annual (summer) analysis. However, Carvalho et al. (2014) identify evident increases (~20% on average) in the annual maximum

daily rainfall for the same region during the rainy seasons (Oct-Mar) of 1940 to 2011. Usually defined as the annual maximum daily rainfall within each year, a growth in this pattern reveals an extreme rainfalls tendency, a pattern identified by Nunes and Silva (2020) who have noticed an increase in the frequency of extreme rainfall events in the greater part of the eastern and northern region of SC. This indicates potential for either rise in the number of floods and landslides or long dry periods that cause water stress (PERCH-NIELSEN, 2010; ROSSELLÓ; BECKEN; SANTANA-GALLEGO, 2020).

Rainfall projections for Itajaí Valley, which includes BC and surrounding cities, show an increase in the extreme precipitation indices Rx1day and Rx5day (mm) for the end of century, 2100 (baseline 1961-1990) (PBMC, 2016). These indices measure, respectively, the accumulated precipitation during 1 and 5 days, the most effective in making the soil saturated and more susceptible to landslides and flash floods (see DEBORTOLI et al., 2017). Moreover, occurrence of hydrological hazards (floods, flash floods, rainstorms, and landslides) in SC has risen at a rate of 22% a year from 1995 to 2014, causing damages of more than BRL 9.8 billion (USD 2.6 billion, 2019 rate; 4% of SC GDP), of which 50% brought by the great flood in 2008 (CEPED, 2016). These facts are in line with the extreme rainfall increase tendency, justifying the score 1 for rainfall patterns.

BC has 29 tourist attractions in total, of which 48.1% have been impacted by the six climate-related events discussed previously, therefore they are exposed (i2) to future changes in climate. The beaches and the cable car that links the city to the city mountain and to other beaches are the main attractions as well as the most exposed ones. For example, lighting storms, wind blast up to 122 km/h, and rainfall events altogether have increased the interruptions in the operationalization of the cable car by as high as 832% in nine years of observations (2012-2020) (based on data of a tour operator report). However, even though these two attractions are very exposed and sensitive (i.e., vulnerable) to climate events, the percentage calculation for the exposed attractions are equally weighted since there is no reference in the literature to justify a different system. In addition, the other beaches nearby combined with

other attractions such as shopping, night life, amusement park, and the good city infrastructure can compensate such temporarily closures, thus, keeping the destination's tourism flow.

4.5.2 Population characteristics

The average of the four indicators that composite this subindex (detailed in Table 4.10) reaches a low level in the Coastourd Index scale, with a final score of 0.382. Educational level (i3) is the greatest contributor to reduce the final score. The Firjan Index for Municipal Development (IFDM), an index that evaluates the same three dimensions of development used by the UN-HDI, has a high score for the education category (0.871). The last ranking report (2018) places BC in the sixth position between the 295 municipalities of SC, a positive result that might have contributed to a relatively low poverty rate of 23.4% (i4), since education is closely correlated to income generation. Comparing to the 295 municipalities in SC, BC positions the 61st place for poverty.

Table 4.10 – Population characteristics subindex variables.

Observable variables	Source	Score
3. Education	IFDM (www.firjan.com.br/ifdm)	.129
4. Poverty	IBGE (2010 data base) cidades.ibge.gov.br	.234
5. Working age population dependency	IBGE (2010 data base) cidades.ibge.gov.br	.298
6. Population density	IBGE (2021 population estimate) ibge.gov.br	.866
	Total score (mean)	**.382**

High educational levels and low poverty rates determine destinations' flexibility to cope with crisis and their capacity to adapt to changes (CINNER et al., 2018; SCOTT; HALL; GÖSSLING, 2019). For example, to tackle the Covid-19 pandemic BC has created a Crisis Committee in the biggening of 2020. The action resulted in the development of successful strategies (see section 4.5.5 for details). Another indicator that contributes to a low vulnerability is the ratio of dependents (i5) per working age adults (aged 15-59), which represents 29.8% of the total population of BC, lower than the national one (35.5%). This indicates a lower proportion of vulnerable in case of hazards (BORUFF; EMRICH; CUTTER, 2005; VINCENT, 2004). On the other hand, the population density (i6) marks the highest score (0.866) in this subindex since BC ranks the first

position in the state of SC (295 municipalities), concentrating more than 3200 inhabitants per square kilometre.

4.5.3 Biophysical and Environmental

This subindex dimension is underpinned by seven variables (Table 4.11), of which two score the highest mark (1) and press up the final averaged result to 0.527, keeping the subindex in the medium level of the Coastourd Index scale. A study developed by the Brazilian Geological Service (CPRM, 2015) for several cities identified that only 8.9% of the urbanized area in BC is classified as low susceptibility to inundation. Another 20.2% present middle susceptibility and 51.2% is highly susceptible to inundation (i7), mainly associated to rainfall and/or storm surge. Such a high rate can be related to the low elevation average (3m) above mean sea level (i8) and to the geomorphological characteristics of the coast (i9), primarily sand beaches and sandy soil that constitute more than 50% of the destination's area (CEPED, 2016; CPRM, 2015), both scoring one and contributing to increase vulnerability in this subindex.

Table 4.11 – Biophysical and environmental subindex variables.

Observable variables	Source	Score
7. Differences in the run-up heights	(CPRM, 2015) Note: area ranking "high" in the Low, Medium, High probability scale level.	.512
8. Elevation above mean sea level	(CEPED, 2016; CPRM, 2018)	1.
9. Coastal geomorphological characteristics	(CPRM, 2015, 2018)	1.
10. Biophysical characteristics	(FERREIRA; MAIDA, 2006; Google Earth	.340
11. Ecosystem diversity and health (marine & terrestrial)	Terrestrial - Intactness Index; Marine – ocean index (see Appendix A3.1 for details)	.188
12. Sewer and water systems & waste collection	National Information System on Sanitation (SNIS). 2019 data base for IN055 and IN056. Note: data set average of water, sewer and waste collection.	.026
13. Blue flag award	www.blueflag.global	.625
	Total score (mean)	**.527**

Coral reefs in the South Atlantic Ocean can be found only in the Northeast coast of Brazil (FERREIRA; MAIDA, 2006). Although there is no coral reef in the South region, BC scores 0.340 for biophysical characteristics (i10) because the

destination presents a relatively high predominance of coastal vegetation (61.3%) in its territory, disregarding the high population density that usually presses the environment. This result is probably connected with the governance system restrictions that democratically control the access to natural resources and force the compliance of rules. Basurto; Gelcich; Ostrom (2013) indicate similar results in the Mexican fishing communities, where a good governance system (fishing monitoring, enforcement of rules) led to an increase of the benthic resources, the primary source to sustain the locals' livelihood in that region.

Coastal and marine ecosystems (i.e., coral reefs, beaches, dunes and mangroves) which have been altered, weakened or removed altogether will consequently be more vulnerable to climate-induced disaster events (UNEP, 2008, p. 23). Then, two indicators are used to evaluate the ecosystem diversity and health of the destination (i11). The Biodiversity Intactness Index (BII) assesses the ecosystem functioning by estimating the percentage of the original number of species remaining and their abundance in a given terrestrial area. The ideal condition for a healthy ecosystem is 90%, whereas 30% or less indicates depletion of the area's biodiversity to an extent below the boundaries for a functioning ecosystem (PREDICTS, 2021). Up to date, the data is available at a country level only and Brazil remains 76.2% of its natural area, scoring 0.238. Similarly, the Ocean Health Index (OHI) is also available at a country level. Brazil scores 0.138 in the four (out of ten) dimensions: biodiversity, clean water, coastal protection, and carbon storage. The average of both BII and OHI results in a low score (0.188) for this indicator, yet it is not specific for the destination's region.

For sanitation system and waste collection (i12), BC presents a high coverage rate (97.4%), and a few percentages of houses (2.6%) lack theses services, contributing to lower the overall score in this subindex. Conversely, two out of the six beaches (Estaleiro and Estaleirinho) and one out of the three marinas (Tedesco) are recognised with the blue flag award (i13), resulting a medium score of 0.625 for the indicator.

4.5.4 Built environment

Four indicators composite this subindex (Table 4.12), which scores 0.284, a low level in the Coastourd Index scale. The infrastructure at Central beach, which hosts the great majority of tourists, is very close to the shoreline (i14) as shown in Figure 4.10 (a) and eventually high tides or storm surges hit the built structure (b) to such an extent that it crosses over the main avenue. Then, this indicator marks the highest score (0.800) for this subindex. On the other side, both the quality of built environment (i15) and the transportation infrastructure (i16) score the lowest (zero) since BC presents a skyline of strong and tall buildings, and easy access offered by a great transportation modal system that includes a wharf for cruise ships, the federal highway (BR-101) that links the entire Brazilian coast, the main Brazilian port located in the border city of Itajaí, and the international airports of Navegantes and Florianópolis, half and one hour distance from BC, respectively.

Table 4.12 – Built environment subindex variables.

Observable variables	Source	Score
14. Infrastructure proximity to the shoreline	Interviews and local observation	.800
15. Quality of tourism infrastructure	Local observation	.000
16. Transportation infrastructure	Local observation; exploratory research	.000
17. ICTs & electricity infrastructures	Interviews	.337
	Total score (mean)	**.284**

The city has a good electricity and Information & Communication Technologies (ICTs) infrastructure (i17) but interruptions in the power force have been reported occasionally by stakeholders (*n*=13). However, it has not caused major impacts on business and other services because blackouts occur for a short period of time, contributing to a low score (0.337) for this indicator. Basic infrastructure may increase destination's assets by improving market accessibility for both, the destination that can access goods from other markets, and tourists that find easy access to the destination, providing greater flexibility and more freedom of choice to respond and manage climate shocks (CINNER et al., 2018). Quality also matters since poor code for buildings and infrastructures have been reported by Calgaro, Dominey-Howes and Lloyd

(2014) as one of the causes that led to structural failure and high mortality rates in Southern Thailand 2004 tsunami. BC buildings are engineer-designed constructions that have received impact of wind blast as strong as 168 km/h, the highest speed ever registered for SC (Rodrigues, 2020).

Figure 4.10 – BC Central beach with its (a) shoreline and (b) high tide.

Source: (a) Eduardo Valente/AGP (2017); (b) Mary Leal (2017).

4.5.5 Tourism-specific sensitivities

Eight indicators form this subindex (Table 4.13), which scores 0.336 in total. The great majority of the tourist flux in BC occurs in the summer, concentrating ~46% of the annual flow. Despite May, June, August, and September receive the lowest number of tourists (17,7%), the annual flux (i18) is quite well distributed along the year lowing the score to 0.250 for this indicator. However, in terms of market diversity (i19), BC presents a medium averaged score of 0.500. This is because BC presents inexpressive number of visitors coming from the greatest domestic and international emitter markets (see Appendix A4.1). The states of SP, RS, MG, RJ, and BA are the five greatest emitter markets of tourists within Brazil (Théry, 2015), and the five greatest international emitter countries of tourists in the Americas are the United States (157.8 million), Mexico (82.7 million), Canada (37.8 million), Argentina (15.3 million) and Brazil (10.6 million) (data.worldbank.org - international tourism, number of departures). This might be an opportunity to invest the marketing efforts to attract tourists from such regions.

Table 4.13 – Tourism-specific sensitivities subindex variables.

Observable variables	Source	Score
18. Tourism seasonality	PMT 2019	.250
19. Diversity of tourism markets	Survey (interviews); Théry, 2015; data.worldbank.org.	.500
20. Reliance on international tourism	Survey (interviews)	.550
21. Diversity of products	Exploratory research; Local observation	.340
22. Destination Marketing Organization (DMO) activity	Exploratory research; interviews	.000
23. Destination's history & positioning	Exploratory research; interviews	.300
24. Destination image – brand position	Interviews; Fecomercio (2020)	.261
25. Tourists' perceptions of climate risk	Interviews	.489
	Total score (mean)	**.336**

The ratio between domestic and international flow (i20) is 0.550 since international visitors respond to 31% of total flux, which makes the destination slightly dependent on domestic market. On the other side, the destination offers a quite diverse number of products (i21) and related attractions including night life, shopping, and parks & adventure, increasing resilience under climate disturbances and reducing the indicator's score to 0.340. Furthermore, the BC Convention & Visitor's Bureau (CVB), which is the DMO, undertakes several activities (i22), lowing the score to zero for this indicator. Promotional videos, workshops with national and regional tour operators, qualification courses to increase labour's skills, and promotion of events have been some used strategies to boost the destination's image and to attract more tourists. CVB also developed a campaign ("Move BC") by the end of 2020 in cooperation with the Committee for Covid-19. The campaign launched an online platform, later converted into an application for smartphones, to attract and guide potential visitors interested in the city's attraction. Visitors could also collect several discount coupons. As a result, the hotel occupation rates have recovered and even overcome pre-pandemic rates (Acibalc, 2020; Smania, 2021).

As presented in section 4.2.1, BC's history demonstrated it has been positioned as a regional destination since late 1920s. However, the destination has been national- and internationally recognised only in the past 2-3 decades, mainly due to investments in the real estate market and tourist attraction diversification (Schlickmann, 2016; Beuting & Martins, 2016). To analyse the destination's

history and positioning (i23), the Butler's (1980) tourist area life cycle (TALC) model were applied. The TALC model states that in the "consolidation stage" the rate of increase in the destination's tourist flow declines but total visitor numbers exceed the number of permanent residents. This pattern can be identified in the summer season, when the rate of visitors surpasses 3.5 times the number of residents in BC. As described in the TALC model, a major part of BC's economy is also tied to tourism, positioning the destination between the "consolidation" and "stagnation" stages, a classification confirmed during interviews with the local institutional stakeholders (n=6), generating a score of 0.300 for this indicator.

The maturity stage associated with an active DMO might have contributed to build a relatively strong destination's image (i24), especially in the domestic and Argentinean market. The following three factors (presented in section 4.3.3) contribute to lower this indicators' score to 0.261 in the Coastourd Index scale: (1) the destination desirability is relatively high, positioning BC ahead of world famous destinations such as Rio de Janeiro and Miami; (2) almost half of respondents have a positive image of the city and another 38% holds a neutral perception; and (3) the revisiting rate is very high since 67.3% of visitors have visited BC five times or more. Note that more than half (52.5%) of tourists interviewed in BC stayed for 4-7 days and 32.1% a longer stay of 8-15 days.

Analyses from sections 4.3.4 and 4.3.5 feed the tourists' perceptions about climate risk indicator (i25). When examining the averaged responses of beachgoers that would "change the destination" and "cancel the trip completely" in the face of weather/climate scenarios that are already occurring in BC, a medium level result of 48.9% (0.489) is found. This might have a great impact in the destination, depending on the intensification and increase of those events. A stakeholder (hotel) emphasised that a 'slow' event such as sea level rise have much lower impact on destinations' image than a flood (shock) caused by intense rainfalls. Any disaster caused by natural events and occurred at any part of the state generates an instant impact for the whole state, including BC.

4.5.6 Economic & social

For this subindex, eight indicators account for the low result of 0.249 (Table 4.14). The economy of BC is very diversified (i26). According to Ibge classification system for economic activities (CNAE), BC's GDP is composed of the main productive economic sectors: agriculture (0.2%); industry (12.5%); public administration, education, health, defence, and social protection (17.5%); and services (69.8%), which include water & sanitation management, financial sector, tourism, transportation, and ICTs – information & communication technologies. From the eleven high-level grouping of economic activities classified by The World Bank (2016), 'Energy & Extractives' is the only one inexistent in the BC's GDP composition, which contribute for a very low score of 0.091 in the Coastourd Index scale.

Table 4.14 – Economic subindex variables.

Observable variables	Source	Score
26. Economic diversity	IBGE cidades; Sebrae, 2019	.091
27. Financial capital availability	Survey (interviews)	.072
28. Business insurance	Survey (interviews)	.643
29. Credit access	Survey (interviews)	.257
30. Job security & welfare safety nets	Ipea - Simt (2012-2015 data) Data available for the region only	.377
31. Local ownership	Survey (interviews)	.000
32. Destination's expertise	Survey (interviews)	.384
33. Population working in tourism	Ibge; Ipea/Simt (formal jobs only)	.168
34. Kinship networks and groups	Non-available	-
	Total score (mean)	**.249**

The availability of capital (i27) to maintain business operating in case of slump in tourist revenue (such as Covid-19 or natural disaster) achieves a rate as high as 85.7% of interviewees, who stated they could sustain their business for a period of 12 months (57.1%) or even more than a year (28.6%). Only a few percentages (14.3%) would be less flexible, staying for no more than six months. Such a result might explain the low rates (0%) of the tourism industry holding insurance that covers physical damages and revenues reduction. However, a high proportion (71.4%) invest on business insurance (i28) that cover only physical damages and 28.6% lacked any type of insurance, supporting the highest score (0.643) in this subindex dimension.

Business lifetime determines the credit availability that companies can access because young enterprises need to develop trust and loyalty when starting up (Biggs et al, 2012). The tourism industry interviews in BC identified that 85.7% of the firms have been operating for more than 10 years, which have offered a relatively good credit access (i29) to business since 42.9% of respondents strongly agreed with the sentence: 'This enterprise has easy access to loans throughout family, friends or banks'. A percentage of 42.9% chose neutral and only 14.2% disagreed. The weighted average yielded a low score value of 0.257 in the Coastourd Index scale. Finally, the rate for tourism formal jobs in the Southern region of Brazil proportionate a relatively high stability in the tourism industry, where 63.3% of employees have access to welfare security nets (i30) due to formality.

The rate for local ownership (i31) within the tourism industry (*n*=7) showed that 100% of enterprises belonged to locals. Biggs et al. (2015) emphasises that local owners usually develop connection and attachment to their place, which may increase the resilience under constraints since they are more reluctant to abandon business. Thus, this indicator scores zero. For the destination's expertise (i32), stakeholders (n=14) indicated a relatively easiness to hire qualified employees in BC and hence a low-level score (0.384). Note that 43% of tourism industry stakeholders (n=7) finished high school, while three-quarters of all stakeholders (78.5%) finished higher education including postgraduation by research (PhD).

From the total working population who has any type of income (45% of the inhabitants) 16.8% are formally hired on tourism related jobs (i33). This represents a relatively low score (0.168) in the Coastour Index scale but a tourism dependency rate four times higher comparing to the state (4.2%) and national (4.5%) averages. Measuring the kinship networks and groups (i34) requires data from employees and self-employed people, especially those who informally trade products (walking workers) at the beach such as food, beverage, snacks, handcraft, and so on. However, the access to these targeted

public was unavailable due to Covid-19 restrictions that precluded face-to-face interviews, or even forced walking workers to abandon the “job”.

4.5.7 Governance system

To assess governance processes that influence VUL/RES in BC, eight indicators are evaluated to compound this subindex dimension (Table 4.15), which has a low final score of 0.224. BC presents a transparent process in terms of access to natural resources (i35) such as beaches. For most interviewees, the resources are democratically controlled and accessible to all according to rules, yielding a very low score for this indicator (0.083). To set up a new enterprise (park) inside a natural area close to the beach, an interviewee contested that “the environmental agency has demanded several studies and mitigation procedures before issuing a permission for our installation”. However, clear and transparent rules were recognised. This might justify the low score (0.206) for transparency (i36) regarding the local government management, measured by the Federal Council for Administration (CFA), and confirmed by means of interviews, in which stakeholders agree that the processes for making decisions are transparent.

Table 4.15 – Governance system subindex variables.

Observable variables	Source	Score
35. Access to natural resources	Questionnaire (stakeholders)	.083
36. Transparency	Municipal Governance Index – transparency subclass; Average of question ‘N’ in Table 4.7 (See Appendix A6.1 for details on calculation)	.206
37. Participation in decision-making process	Average of questions ‘O’ and ‘P’ in Table 4.7	.172
38. Destination trustworthiness	Average of stakeholders’ result for questions ‘K’ and ‘L’ in Table 4.7	.236
39. Political & civil stability	Average of stakeholders’ result for questions ‘M’ and ‘Q’ in Table 4.7	.250
40. Flexibility (autonomy)	Average of questions ‘R’ in Table 4.7	.343
41. Government accountability	Siconfi 2013-2019 series	.500
42. Government responsibilities for natural disaster	Interviews	.000
	Total score (mean)	**.224**

In BC, transparency in the decision-making processes is correlated to stakeholders’ representation in participation of decisions (i37). Such

participation occurs through institutional representations – CVB, associations, and the local and regional councils for tourism – thus, it has a very low score for the indicator (0.172). All these factors might contribute for a high trustworthiness rate (0.236, i38) since stakeholders demonstrated high levels of trust for doing business in BC as well as a fair perception for solving conflicts by institutions. These three factors (transparency, representation, and trust) reflect in the conflict-solving process, that is considered democratic and fair without distinction between small and big groups. Additionally, actors respect decisions taken, which brings stability in the political and civil arena (i39) and a low-level rate (0.250) in the Coastourd index scale.

Trustworthiness also connects to decentralisation. The tourism industry has a relative autonomy (i40) to taking decisions that concern specific segments, ranking 0.343 in this indicator. In terms of accountability (i41), the rate between expenditures and revenues is 87.4% on average for years 2013-2019, which indicates that BC government keeps a fiscal health controlling, spending less than its incomes. However, a lower rate could offer more opportunities to invest in other important areas such disaster risk reduction, mitigations strategies and adaptation, thus a medium score (0.500) for this indicator and the highest in this subindex. On the contrary, the responsibilities for natural disasters (i42) marks the lowest score (zero) given that the destination's government has clear understanding about its role when a disaster happens. Each institution knows its competences, what and when to do in case of an emergency and also how to proceed afterwards. However, local government institutions lack better integration with state government institutions in the context of environment and tourism. The local Civil Defence (CD) expresses better relations with the state level institution for CD.

4.5.8 Impact and coping responses

Five indicators composite this dimension (Table 4.16), generating a low score of 0.336. The great flood of 2008 was the most extreme climate-associated event occurred in SC and in BC, impacting people and their livelihoods, including tourism. However, despite the creation of a Municipal Commission for CD in

1996, there is no published emergency plan - EP (i43) in BC, but there is one in progress according to the local CD. However, the plan does not integrate tourism into sectoral actions, justifying the score 0.750 for this indicator. The National Policy for Protection and CD (Act 12.608/2012) provides guidelines to build a Protection and Contingency Plan for CD. This plan must be arranged by the CD director, as determined by the Act 4.007/2016 that created the Municipal Fund for Protection and CD. The recent local policy for Water Security and Sustainable Development (Act 4.560/2021) also recognises the local government responsibility to implement disaster risk reduction actions. This Act states the CD plans must consider sectoral plans for emergency and contingency, an opportunity to integrate tourism into the future plans.

Table 4.16 – Impact and coping responses subindex variables.

Observable variables	Source	Score
43. Emergency Plan (EP)	Exploratory research; interviews	.750
44. EP for tourism industry	Interviews; Tourism industry's result for question 'D' in Table 4.7	.386
45. Warning system	Tourism industry's results for questions 'E' and 'F' in Table 4.7	.357
46. Responsiveness	Stakeholders results for question 'G' in Table 4.7; Institutions interviews.	.186
47. Immediate recovery	Exploratory research; interviews	.000
	Total score (mean)	**.336**

The tourism industry shows a better preparedness to cope with ENE since most of enterprises (57.1%) has an action plan (i44) that describes safety procedures in case of an ENE occurrence. The required infrastructure is built, and staff are regularly trained, therefore, a low score (0.386) in the Coastourd Index scale. Communication is another vital component to reduce the risk of disaster in the destination. In this regard, the warning system (i45) in BC presents a low-level score (0.357) since the tourism industry usually receives early warning communication from official authorities. However, this system needs integration with other institutions, specifically those related to tourism in order to provide a better response.

Emergency plans and warning systems contribute to a quicker responsiveness (i46) under an imminent trigger event, thus lowing the risk of a disaster to 0.186.

Although the plan is not published, stakeholders have clear identification of responsibilities to coordinate and act immediately pre-, during, and post-event. Moreover, stakeholders have already implemented safety procedures following a warning communication, as detailed in section 4.2.2.3. The CD conducts regular training (flood simulation) involving several institutions such as the SC Federal Institute, the local Social Development Secretariat, the Firefighter Corporation, and the local Secretariat for Education, since schools serve as a shelter for inhabitants following a disaster. This clear understanding of responsibilities and the simulation preparedness influence the immediate recovery (i47) in BC, which usually takes few days to rebuild the destination, reducing the impact on tourism, which generates a zero score for this indicator.

4.5.9 Adjustments and adaptation

To composite this subindex eight indicators provide information (Table 4.17), yielding a final score of 0.460 in the Coastourd Index scale. As discussed previously, the local emergency plan to reduce the risk of disasters in BC is unpublished. However, the CD representative informed during the interview that the plan is under an updating process. This means that it is being monitored (i48) to include new factors and will be published when ready, thus, having a low score of 0.340 for this indicator. Tourism stakeholders of BC are aware and informed about the potential negative impacts of extreme natural events (risk of natural hazards) and climate trends (i49). According to details in section 4.2.2.3, most stakeholders have developed some action to check staff awareness, reason for a low score of 0.229.

Launched in early 2021, the state level Programme “Recomeça SC” (Restart SC) provides financial support for enterprises affected by natural and climate-associated hazards. The Programme aims to boost economic recovery to reduce impacts on livelihoods at the municipalities of the state. In addition, the BC Fund for Protection and CD (Act 4.007/2016) allocates resources (i50) to develop strategies for preventing disasters and to assist during and post event. These actions increase resilience, therefore, reduce the indicators score to as low as zero. Despite these recent policies interventions (i51), they do not reflect

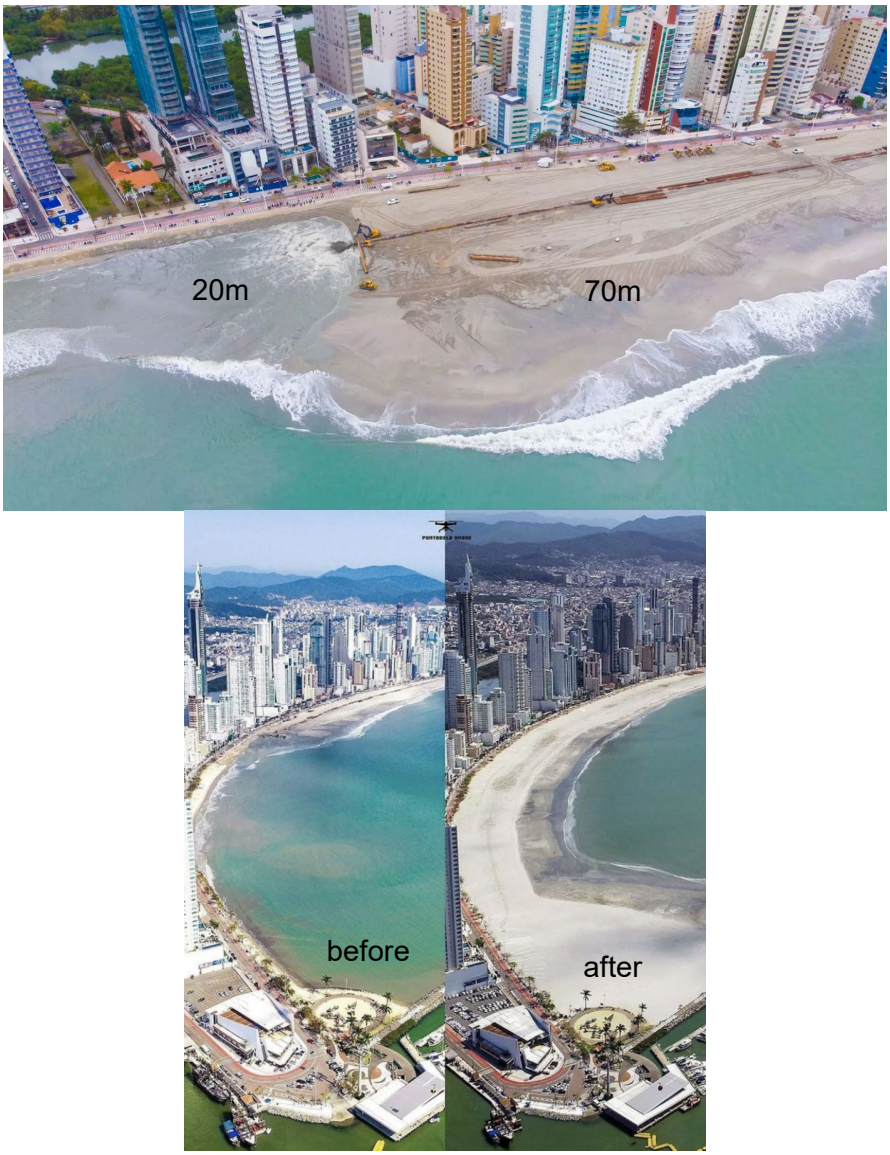
into a local multi-sectoral cooperation and integration, as strongly advocated by UNDRR (2017). This would facilitate and support specificities needed by distinct sectors, including tourism. For instance, tourists face more challenges to cope with ENE since they are not familiar with the destination as the locals are. Thus, this factor affects the capacity of the tourism stakeholders to tackle climate constraints, thus scoring 0.560, a medium level in the Coastourd index scale. Specific policies to deal with climate change could contribute to minimize the lack of multi-sectoral integration. However, BC has no climate policies (i52) and the mentioned policy for Water Security and Sustainable Development only focus on water shortages, one in many factors related to climate change, increasing the score to the highest mark (1.000).

Table 4.17 – Adjustments and adaptation subindex variables.

Observable variables	Source	Score
48. Monitoring of emergency plan	Interviews; exploratory research	.340
49. Information on risks & trends	Stakeholders' results for questions 'A', 'B', and 'C' in Table 4.7	.229
50. Public budget allocation for DRR	Interviews; exploratory research	.000
51. Policy and planning interventions for tourism integration	Interviews; exploratory research	.560
52. Climate change policies	Interviews; exploratory research	1.000
53. Biophysical reorganization	Interviews; exploratory research	.340
54. Flexibility of the industry to changes	Interviews	.714
55. Disaster risk learning and exchange	Stakeholders results for questions 'H' in Table 4.7	.500
	Total score (mean)	**.460**

The zoning and land use plan of BC (Act 2.794/2008) dates from 2008, same year of the great flood occurred in the whole Itajaí Valley. However, since then the city did not review the plan to reorganise the space (i53) and integrate climate risk. Inappropriate land management and land use actions, including development in flood zones, contribute to increase exposure to risks (TOUBES et al., 2017). Yet the city has chosen beach nourishment as an infrastructure strategy to adapt to SLR and reduce the impacts of storm surges, the main problems faced by BC. As a result, in 2021 the most important beach for BC has been enlarged from 20m to 70m width (Figure 4.11). This strategy does not integrate any DRR plan or climate risk policy and planning, then it scores 0.340.

Figure 4.11 – Beach nourishment at the Central Beach in BC.



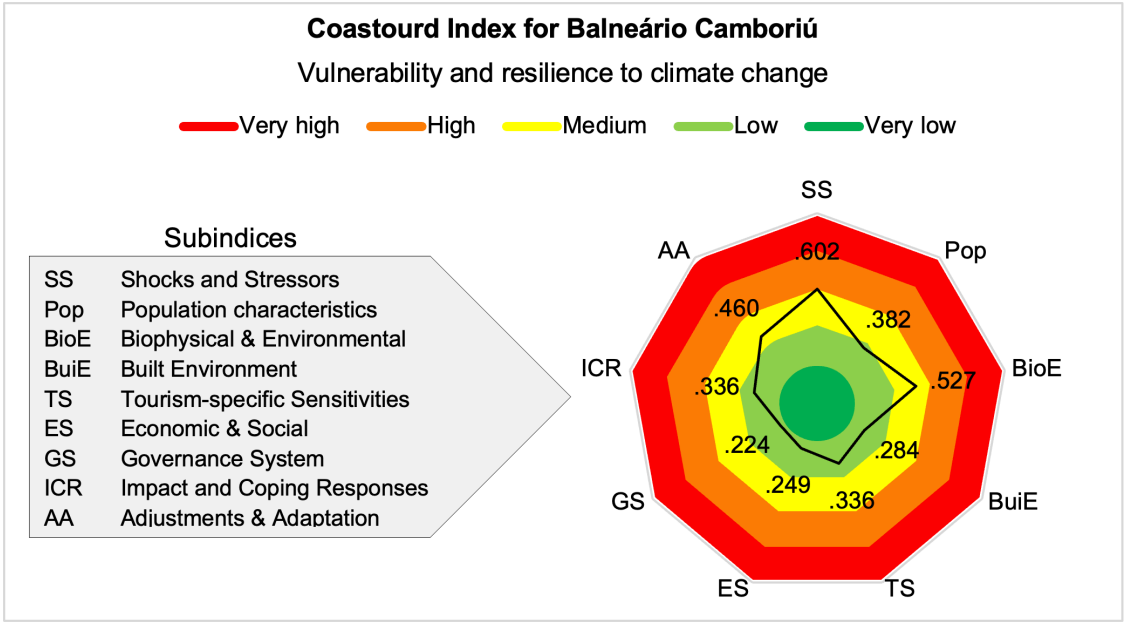
Source: BC town hall (2021).

Flexibility is another factor that contributes to increase/decrease resilience. The tourism industry's flexibility (i54) is very limited since 71.4% of them (0.714) rely on just one source of income. Crisis such as Covid-19 pandemic affected the tourism in the destination, and consequently some businesses can be forced to abandon the market, so that decreasing destination resilience. To amplify the problem, the tourism industry and other stakeholders have little participation in exchanges with other institutions to sharing knowledge, capturing resilience best practices, issues, and disaster risk responses that could be learnt (i55). Then, this indicator has a medium score of 0.500.

4.5.10 The Coastourd index result for BC

The Figure 4.12 summarizes the overall result of the Coastourd Index for Balneário Camboriú. The SS subindex marks the highest score (0.602) amongst the nine dimensions (or subindices), the only one placed in the 'high' level of the Coastourd index scale. Positioned in the 'medium' level scale are the BioE and AA dimensions, scoring 0.527 and 0.460 respectively. The remaining six dimensions (the great majority) rank in the 'low' level scale, where the highest of them (Pop) scores 0.382. TS and ICR have the same result (0.336), followed by BuiE (0.284), ES (0.249), and GS (0.224) the lowest among all nine subindices. Note that none of all nine dimensions ranks in the 'very low' and 'very high' levels, indicating that the destination of BC has a medium-low VUL/RES to the changes in climate. Despite potential impacts caused by SS, the destination presents a medium-low vulnerability and a medium-high capacity to cope with such SS.

Figure 4.12 – The final Coastourd index score for BC comprising the nine subindices.



4.6 Concluding remarks

The Coastourd Index has proved to be a promising tool for the VUL/RES assessment of BC. This is because the data collected on ground reflect the local contexts and specificities that are unique. It also provides information for

stakeholders to track the factors that impact the tourism at this destination. For example, the current shocks and stressors such as SLR and storm surges that have been impacting the main beach (Central Beach) might increase in the frequency and intensity. However, the recently built adaptation measurement (beach nourishment) can reduce the floods and other damages on infrastructures that have been occurred, therefore differing the score for dimensions SS and BioE in a future analysis.

This assessment also emerges as an opportunity for BC to boost its resilience by developing actions for the indicators grouped in the AA dimension. For instance, introducing climate change policies and implementing a forum or similar spaces to promote exchange and learning about DRR amongst cities in the region strengthen the region's resilience. This create a positive feedback since BC is important for other surrounding destinations, and at the same it benefits from these cities' infrastructures such as the Itajaí port and Navegantes airport. On the other hand, the Coastourd assessment has shedded light on the good local governance system (the lowest score) that shows compliance with principles of justice and other norms recognized as universal for democratic societies, e.g., transparency and participation in decision-making processes.

Overall, the application of Coastourd has shown on one side the factors that constraint the tourism SES in BC, and on the other side, it has highlighted the opportunities to adapt and increase the destination's resilience in the face of a changing climate. Nevertheless, it is important to note that some isolated actions, such as the beach nourishment, must integrate a broader planning that looks at the whole destination as a system with intra- and interactions within the city and external destinations. This would avoid undesirable outcomes due to maladaptation strategies. For example, the beach nourishment might impact negatively the marine biodiversity, increasing the destination vulnerability. Integrating plans into a reginal planning can also pave the way for climate-smart projects, which is considering the future and current ENE into their strategies such as those taken by the park that hired forecast services for its operations, therefore, increased its resilience.

5 CONCLUSIONS

The focus of this thesis was the development of a methodology that could combine a qualitative-quantitative approach to evaluate the vulnerability and resilience of coastal tourist destinations to climate change. The proposed novel and generic Coastal Tourist Destination Index (Coastourd) proved to be a promising tool to help coastal destinations worldwide to map out the factors that cause vulnerability (constraints) and increase resilience (opportunities) in the face of a changing climate. Coastourd emerges as a promising methodology because it contributes to cover several gaps:

1. The needs of qualitative-quantitative analysis of CC and tourism at a local level.
2. The enormous geographical gap in South America since it is the first assessment applied in the continent.
3. The contribution to increase the literature on CC and tourism.
4. The need for a flexible framework that can be applied to different destinations and contexts.

This final section synthetises (1) the major findings of the thesis and their importance; (2) the main limitations and implications concerning the methods adopted in this investigation; and (3) the recommendations for future studies to deepen the knowledge on the tourism and CC over South America and other places.

5.1 Major findings

This thesis is structured into four sections. The first one describes the understanding of the tourism development and its related concepts that are important to define limits and frame the focus on the object under investigation. In the case of this study the focus is a tourist destination and its respective tourism system, portrayed as a SES. The concept of a tourist destination has also shedded light on the importance of its definition to shape the methodological process and the research design, as emphasised by Pearce (2014). The flexible geographical scale of the analysis looking at the destination

as a unit allows users to address issues at a local level, be this unit a city, region, state/province, or even a spatially small country.

The second part of the thesis deeply explored the literature to compare and find the most suitable framework to develop a novel model that could embed qualitative-quantitative methods. Eleven frameworks were analysed based on a set of criteria (shown on Table 3.2) and DSF emerged as the most appropriate for the purpose of creating an index. As a result, 55 indicators have been suggested to composite the nine dimensions classified in the novel Coastourd Index, a tool to measure the VUL/RES of tourist destinations to climate change. The simple method of aggregating indicators in the Coastourd index avoids space for subjectivity and facilitate understanding, thus achieving the purpose of indices, which are: (1) to encapsulate a complex reality that frequently has an intangible process but possible to be "ground truth" (Vincent, 2004); (2) to be valid, applicable, feasible, and useful for decision makers; (3) to offer relatively low-cost to collect data; and (4) to add utility for target actors in supporting them into taking actions (CLARK-GINSBERG et al., 2020; VINCENT, 2004).

The third part of the thesis comprises data collection and their results. Tourists and other stakeholders (the tourism industry and institutions) informed 32 out of the 55 indicators. The tourists' perceptions revealed that they are sensitive to climate extremes, avoiding travels to destinations with unsure or unstable climate. Hurricane, drought, and severe storms are the scariest extreme events for visitors, who generally prefer to change destination or cancel the trip altogether. However, building a strong destinations image is one factor that increases resilience to this type of climate-associated hazard. As shown in the case of BC, Miami (very internationally recognised destination) is less desirable for Brazilians than BC. Additionally, the tourist survey identified opportunities to raise funds (tourist tax) to implement mitigation and adaptation actions to CC. Several destinations such as Fernando de Noronha Island and Jericoacoara National Park have been applying nature conservation taxes for decades. Most tourists expressed their willingness to pay tourism tax for adaptation, and this

potential finance resource could be used to boost resilience in the whole region of BC since climate hazards in the cities nearby also reverberate in BC.

The last part of the thesis presents the results of applying the Coastourd Index. The analysis emphasised (1) the most vulnerable subindices (where more attention should be paid to the SS, BioE, and AA dimensions) and (2) the most resilient subindices (notably GS and ES dimensions). Most of the events listed in Table 3.3 have a positive tendency of occurrence and they are captured in the SS subindex, which marks the highest score amongst the nine dimensions. The stakeholders' perceptions of climate risk also confirmed such a tendency, showing that stakeholders have a precise and accurate observation of the changes in climate and the potential impacts on the destination and their businesses.

On the opposite side, the lowest score is for the GS dimension, which draws attention to broader issues of power distribution and governance and how a wide range of institutions and actors (e.g., the travel agencies in BC) negotiate for desired resources (e.g., the excursions in the region of BC) using a series of formal and informal networks (e.g., the creation of the travel agency association) and partnerships as pointed out by Calgaro et al (2014). This result for GS confirms previous findings by Summers et al. (2018) who identified that good governance strengthens resilience to natural hazard events and possibly, to climate change.

Despite the 'very low' and 'low' scores respectively for immediate recovery (ICR) and tourism seasonality (TS) indicators for BC, destinations must consider that in a scenario where ENEs occur in the low tourist season, damages in the infrastructure may be challenging to repair in time for the high season, as indicated by Toubes et al. (2017). Moreover, destinations have to prepare for dealing with a second significant damage, which is on their image that affects tourist flow. ENEs are usually intensified by media and notice on the news. For example, we can mention the infrastructure damages consequences of the very recent disaster (mudslides) that occurred in the very touristic highland destination of Petrópolis-RJ (Brazil) in Feb 2022. It will take a long time

to rebuild the city, and the damages on the destinations image that took international proportions might strengthen the problem by affecting the number of potential tourists in the following high season.

5.2 Research method limitations

The major limitations faced in this work are detailed bellow:

1. Defining the spatial limits where the data will come from might be challenging for researchers who are unfamiliar with the study area.
2. Destinations other than geopolitical limits of BC should provide data for some indicators. For example, impacts of the SLR in the adjacent cities of Navegantes and Itajaí have potential to affect BC as well since the main airport and the port, which are in these cities, might suffer from the elevation above mean sea level.
3. Many indicators apply only post-disaster, meaning the destination should have tried any shock and/or stressor to provide enough data for several indicators. For example, if water scarcity is not a stressor in the longer-term, then droughts wouldn't make sense as an indicator for SS dimension.
4. Indicators are a snapshot of a specific period; therefore, it requires monitoring the factors by gathering information from time to time.
5. Projecting scenarios are useful tools to ask tourists to imagine what their likely reactions would be in the event of climate change impacts on a destination that attract them the most. However, in the face of such uncertain situations, studies can only depict a real understanding of how tourists' intentions will translate into actual behaviour once climate change impacts become evident.
6. Covid-19 pandemic caused a significant impact on data collection. During normal conditions, a larger sample of stakeholders' interviews would provide more realistic information of the situation in the destination.

7. Engaging stakeholders to provide information might challenge researchers. This can jeopardize the entire study since more the half of indicators have data informed by stakeholders.
8. A lack of robustness tests such as multivariate data analysis associated with qualitative examination might indicate redundancy of factors. Thus, the exclusion of indicators may facilitate the application of the Coastourd Index. Decision-makers only have limited resources for data collection and analysis, and tools must be structured to minimise expenditures while maximising benefits.

5.3 Opportunities for future research

The Coastourd Index comprises many “grounded truth’ indicators to identify the multiple and interacting factors that influence VUL/RES of coastal tourist destinations to CC. This provides opportunities for several future types of research. Firstly, Coastourd has the potential to assess different sectors within the tourism industry by rearranging, excluding or adding some indicators, and aggregating into areas such as accommodation, food, artificial and natural attractions, and transportation system and access, so that a more specific and detailed assessment could help these segments to develop and improve. Secondly, it allows for future comparison with other destinations, considering local, regional, and national contexts.

Thirdly, in terms of climate change projections, future studies should evolve to computational modelling by coupling future climate projections and potential scenarios that capture the dynamism inherent to complex adaptive systems such as the tourism SES. These studies can aggregate the magnitude, frequency, and duration of events in the index calculus for a better accuracy. Fourthly, considering that CC has a significant impact on biodiversity, more research is needed on the psychological issues to investigate the tourists’ contradiction of changing destination under a biodiversity loss. Tourists have assigned a relatively lower importance to biodiversity attributes as factors for choosing a destination. Also, sea surface temperature was appointed as the third most important attribute (53%) in seven for beachgoers (n=396), behind

sunny weather (60%) and water transparency (64%). Therefore, projections for sea surface temperature should be included in the analysis once data are available.

Finally, Coastourd Index might serve as a guide for other similar assessments. For instance, the Brazilian platform AdaptaClima aims to disseminate knowledge regarding adaptation to CC. The platform compiles information, tools, and scientific material produced by and for distinct thematic including tourism. This translates into an opportunity for Coastourd Index to be applied in other coastal destinations, especially Northeast Brazil, where tourism represents about 5-6% of the regions' GDP, and beach tourism is the main asset. Likewise, the Brazilian Network for Research on Global Climate Change (*Rede Clima*) produces analysis about the State of Art in the field of climate change to support sectoral public policymaking. The *Rede Clima* focuses on studies about impacts, adaption, and vulnerability for sectors and relevant systems including agriculture, water resources, biodiversity and ecosystems, coastal zones, cities, renewable energies, and health. Coastourd Index cover several of these topics, which also interact with the tourism SES.

Furthermore, the Horizon Europe Framework Programme (HORIZON) calls for research and innovation actions in support of the implementation of the Adaptation to Climate Change Mission. Funded by the European Union, the programme is currently searching (2021-22) for projects to develop climate change risk assessments in European regions and communities, where tourism is an essential source of income, another opportunity for more research using results from Coastourd Index.

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APPENDIX A – INDICATORS DATA SOURCE, CALCULATIONS, AND JUSTIFICATIONS

A1 – Shocks & stressors subindex

A1.1 – Indicator 1. Climate & natural events tendency

No reference in the literature were found to stablish a measurement unit for an increase/decrease in the climate and natural events occurrence or tendency. Therefore, the ranking system for this subindex is zero (0) if there is either a decrease tendency or a stability in the events occurrence; and one (1) if an increase tendency is identified. Note that the best data input for this subindex would be projections for each event at a regional scale. However, most of the models available until so far are at a global level or regional scale for developed countries. Therefore, data for shocks and stressors tendency are based on past occurrence or future projections when available. The analysis considered only studies from scientific research or official reports.

Event	Score	Source
1. SLR	1.000	IPCC (2021) – Chapter 9; IPCC AR6 Sea-Level Projection tool available at https://sealevel.nasa.gov/ipcc-ar6-sea-level-projection-tool?psmsl_id=542
2. Storm surge	1.000	PBMC (2017)
3. Hurricane	0.000	(MCTAGGART-COWAN et al., 2006)
4. Earthquake	0.000	http://rsbr.gov.br/catalogo_sb.html
5. Wind blast	1.000	PBMC (2016)
6. Temperature	0.500	Bitencourt et al. (2020); Marengo; Camargo, (2008); Minuzzi (2010); Steil et al. (2020)
7. Sea surface temperature	N/A	No studies or data available
8. Rainfall	1.000	Gonçalves; Back (2018); Porto de Carvalho et al. (2014)
9. Droughts	1.000	CEPED (2016), PBMC (2016)
10. Hail	1.000	PBMC (2016)
Mean	0.722	

A1.1 – Indicator 2. Attractions exposed

The local Tourism Planning provide a list with all the tourist attractions in the destination. Therefore, local observations combined with interviews verified the number of attractions under exposure to the shocks and stressors listed previously. Attractions that have been impacted for at least once in the past twenty years are considered exposed.

A2 – Population characteristics subindex

A2.1 – Indicator 5. Working age population dependency

Data for this indicator is out of date because the 2020 census has been rescheduled to 2022 due to Covid-19 pandemic. Then, IBGE data dates from 2010 (cidades.ibge.gov.br) and consider as dependent the population from zero to 14 (19,451 inhabitants) and over 60 years old (12,763 inhabitants) as defined by Brazilian public policies. The total population of BC in 2010 was 108,089 inhabitants.

A2.2 – Indicator 6. Population density

For this indicator, the study uses data from IBGE (cidades.ibge.gov.br), which estimates the population for 2021. The calculus considers the highest and lowest population density in the state (SC) and in the region (South) using the normalised formula below:

$$Nv = \frac{actual\ value\ - minimum\ value}{maximum\ value - minimum\ value}$$

where Nv is the normalised value. The average for the state (1.000) and regional (0.731) values is 0.866. The data collected is presented in table X

Place		Density(km^2)
BC		3300,5
SC	min	1,85
SC	max	3300,5
Region	min	1,42
Region	max	4515,4

A3 – Biophysical & environmental subindex

A3.1 – Indicator 11. Ecosystem diversity and health (marine and terrestrial)

For this indicator two indices are used to composite the average score of 0.188. Data for both indices are available at a national level only. The Biodiversity Intactness Index (BII), hosted by the Natural History Museum (UK), is an estimated percentage of the original number of species that remain and their abundance in any given terrestrial area, despite human impacts. If the BII is 90% or more, the area has enough biodiversity to be a resilient and functioning ecosystem but if it is 30% or less, the area's biodiversity has been depleted to such an extent that it is below the most generous boundary of what is needed for a functioning ecosystem (Hudson et al., 2016). The data is available at a country level only and Brazil remains 76.2% of its natural area, then scoring 0.238 (https://www.nhm.ac.uk/our-science/data/biodiversity-indicators/biodiversity-intactness-index-data).

The Ocean Health Index provides an ongoing assessment of ocean health based on ten dimensions. However, four dimensions are applied to achieve the indicator's purpose of assessing the health of the ecosystem: biodiversity (90), clean water (60), coastal protection (97), and carbon storage (98) dimensions. Their average (86,2) indicates a high score for the ocean health in the country that scores 0.138 in this Coastourd Index indicator (http://www.oceanhealthindex.org/region-scores/scores/brazil-+-trindade).

A4 – Tourism-specific sensitivities subindex

A4.1 – Indicator 18. Tourism seasonality

Data for this indicator is provided by PMT (2019) for the years 2018 and 2019. The average of both years is used to inform the indicators result.

	Number of tourists	
Month	2018	2019
Jan	805018	775140
Feb	495312	412606

Mar	338512	337171
Apr	229667	263149
May	166574	187081
Jun	170970	165154
Jul	200514	220996
Aug	147653	153986
Set	204048	160571
Oct	255129	263712
Nov	304836	322370
Dec	520993	525953
Total	3839226	3787889
SD	187637	175367
Mean	319935,5	315657,4
CV	0,5865	0,5556

A4.1 – Indicator 19. Diversity of tourism markets

Standard deviation calculation for international (1.47) and domestic (1.04) flow uses data from the *in-situ* survey (*n*=396) as presented in section 4.3.1. Data to identify the five most emitter countries in the Americas are available at data.worldbank.org (international tourism, number of departures) for year 2019, before Covid-19. Théry (2015) provided data for the five states that respond to more than half of the domestic flux in Brazil.

Rank	**Country**			**State**		
		Visitors	Share %		Visitors	Share %
1	**United States**	0	0	**SP**	62	15,6
2	**Mexico**	0	0	**MG**	7	1.7
3	**Canada**	0	0	**RJ**	14	3.5
4	**Argentina**	86	21.7	**RS**	64	16.1
5	**Brazil**	274	69.2	**BA**	1	0.2

A5 – Economic & social subindex

A5.1 – Indicator 33. Population working in tourism

Data regarding the number of workers with income (*pessoal ocupado assalariado)* is provided by IBGE, the Brazilian Institute for Geography and Statistics (cidades.ibge.gov.br). The period of 2013-2019 sum 330,857 workers and the number of formal workers in tourism-related activities (*atividades características de turismo* - ACT) for the same period totals 55,587 and it is provided by IPEA, the Brazilian Research Institute for Applied Economy (www.ipea.gov.br/extrator). The ratio between the two values (55,587 / 330,857) results the 16.8% for BC. The same calculus is used for SC (648,679 / 15,350,448) and Brazil (14,610,065 / 323,876,318).

A6 – Governance processes subindex

A6.1 – Indicator 36. Transparency

The Municipal Governance Index (IGM) are composed by three dimensions: (1) finance, (2) management, and (3) performance. Another three indicators composite the management dimension, including transparency. The calculation uses the means for IGM – past three years: 2019 (9.82), 2020 (8.15), and 2021 (7.31) – and for question 'N' in Table 4.7. The IGM is available at https://igm.cfa.org.br/dimensao/MjgxODI=/Mg==#dimension2_2.

APPENDIX B – QUESTIONNAIRES

B1 – Tourists' perceptions questionnaire

English (Same questions for Portuguese and Spanish versions)				
Which Brazilian beach destination have you visited last time?				
When? (mm/yyyy)				
What was the main purpose of this trip? Business/Professional Event/convention/conference Leisure/Recreation/Holidays Visit friends/Relatives Education Religion/Pilgrimages Health treatment Other				
Which activities do you engage with when visiting beach destinations? (Choose all applicable) Beach relaxation/sunbathing Walking/running on the beach Trekking Swimming Snorkeling Diving Jet skiing Surfing/windsurfing Fishing Biking/cycling Wildlife observation Other				
Please list 3 beach destinations that you would like to visit in the next 12 months.				
Which destination from the list below have you ever visited?				
Please, classify the destinations below according to your desire to visit or revisit it/them?				
Do you know what climate change is? a) Yes b) No c) Unsure				
I'm aware of the types of extreme climate events.				
Climate change has already impacted or can impact my Holiday trips.				
I feel responsible for my contribution to the climate change				
I always purchase travel insurance for my domestic trips				
I always purchase travel insurance for my international trips				
I have a very positive image of the destination: X or Y				
In the week before your departure to a 5-day holiday trip to a beach destination, you discover that there is a risk of bad weather at the destination. In the face of the listed events below, you decide: (T) To travel and take the risk (P) To postpone your trip but keep same destination (C) To choose a different destination, keeping the dates (X) To cancel your trip completely				
	T	P	C	X
severe storms in some days				

severe storms for the next 7 days				
raining forecast for some days				
raining forecast for the next 7 days				
storm surge in some days				
storm surge for the next 7 days				
hailstorm				
hurricane				
drought (water scarcity)				
In a scenario of the listed events below at the beach, what would you do? (T) I'd travel, no problem (P) I'd postpone my trip, keeping same destination (C) I'd choose a different destination keeping the dates (X) I'd cancel my trip completely				
Beaches disappear up to 30%				
Beaches disappear up to 50%				
Beaches disappear ≥70%				
Streets are frequently flooded as a result of rain or storm surge				
Tropical diseases more frequent				
Increase of storms throughout the year				
Marine biodiversity largely disappears				
Corals severely bleach				
At the beach, which temperature (in °C) do you consider as: (please, type)				
Scaling from 0 to 5, what is the daily rain condition you consider at the beach as: (please, type a number for each one) Ideal Tolerable Unacceptable Note: 0 = no rain 1 = up to 1hr a day 2 = up to 2hrs a day 3 = up to 4hrs a day 4 = up to 6hrs a day 5 = more than 6hrs a day				
Scaling from 0 to 5, what wind condition do you consider at the beach as: (please, type a number for each one) Ideal Tolerable Unacceptable Note: 0 = no wind 1 = light breeze (1-11 km/h) 2 = moderate wind (12-27 km/h) 3 = strong wind (28-48 km/h) 4 = very strong wind (49-87 km/h) 5 = storm (88-117km/h)				
How much of local fee would you be willing to pay to visit a beach destination that needs to implement an adaptation program to climate events? Nothing Up to USD 2 Up to USD 5 Up to USD 10				

Up to USD 15 Up to USD 20 Another
If this destination was Balneário Camboriú, how much would you be willing to contribute to its adaptation?
Please, briefly justify your answer to the previous question

Socioeconomic info

1) City/State/Country
2) Age
3) Gender
4) Income
   Hasta USD 510
   USD 511 - USD 1020
   USD 1021 - USD 2550
   USD 2551 - USD 5100
   USD 5101 - USD 10200
   Above USD 10200
5) Education level
6) E-mail

B2 – Stakeholders' perceptions

The questions below were applied for both stakeholders: tourism industry and institutions. However, institutions had to answer additional and specific questions regarding each of the indicators that were applicable.

English version (Applied in Portuguese)
Do you know what climate change is? a) Yes b) No c) Unsure
Questions **2-18** in the Likert scale Strongly agree Agree neutral Disagree Strongly disagree
Climate change has already affected or may affect my business/company
I know the potential harms of extreme natural events (ENEs)
I know how ENEs may impact my business/company
I have developed actions to check if my staff are aware of the potential hazards that ENEs may cause.
I usually receive or have received (through SMS, E-mail, etc.) early warning communication from official authorities about potential climate risk (e.g., flood, thunder storms, hails, storm surges, and so on.

This business/company has safety procedures in case an ENE happens.
This business/company has already implemented safety procedures following an early warning communication
I really trust in doing business at this destination. People are trustworthy, employers respect agreements, and businesses run safely.
When a conflict rises up the local or subnational/national institutions act to fairly solve it. (Please, give detail)
I feel represented in this destination. My ideas and suggestions for tourism are discussed and debated.
The decisions taken at the destination are transparent. E.g., decisions about rules for: a) opening a new small business; b) accessing public natural/artificial resources such as beaches; c) destination zoning or opening hours for clubs, bars, restaurants, etc. (Please, provide further comment)
The sector where I work has relative autonomy and flexibility to take decisions concerning only our sector. The local and state government respect decisions. (E.g. club and bar opening hours, spatial reorganization for passengers pick-up and drop-off, etc.)
Institutions and organizations (government, justice, legislative power, and representative NGO's,) respect decisions taken.
Conflicts are solved throughout democratic and fair mechanisms that consider small and big groups equitably.
It is easy to hire skilled and qualified employees in this destination.
This business/company has, or takes part in an early warning system for ENEs
This business/company takes part at least annually in group discussion or forums for exchanging experiences about disaster risk associated with ENEs, aiming to learn from past events either at this destination or other places.
Business/company has enough in liquid assets (savings or shares that can be easily liquidated) to run the business over: - Less than 2 months - Max. 3 months - Max. 6 months - Max. 12 months - More than a year
How can ENEs affect my business/company, even indirectly?
Mark which of the listed events have affected (B) your business (D) only the destination (NA) non-applicable or unsure

Event	B	D	NA
Sea level rise			
Storm surge			
Damaging caused by high winds			
Hurricane/typhoon			

Weather changes - increase in cold- heatwaves			
Gradual changes in the temperature (colder/warmer and/or less cold/warm winter and summer)			
Changes on seawater temperature (colder/warmer)			
Changes in the rainfall and storm patterns: more/less often and intense			
Water shortage (water stress)			
Earthquake			
Hail - increase/decrease on frequency and intensity			

This business/company has a partnership or any kind of project with, or is associated with international organizations (IATA, NGOs, UNWTO, etc.)

a) Yes, which one/s?
b) No

List three institutions (private or public, local or international) with which your business has a supportive connection, e.g., training, business agreement/partnership from other companies, government, etc.

In case of an emergency or disaster, the business/company has: (Likert scale)

No credit history with any agent and no family or friends to draw upon
Easy access to get loans (from financial institutions, family members, and/or friends)

This business/company has insurance that covers revenue loss or infrastructure damage

a) No, it does not have any insurance
b) Yes, but it covers either assets or income losses
c) Yes, it covers assets and income losses

Years of the business/company at the destination

a) Less than a year
b) 1-2 years
c) 3-5 years
d) 5-10 years
e) More than 10 years

Do(es) the business owner(s) reside at this destination?

a) Yes
b) No, where?

Relating to information & communication technologies (ICTs) and electricity, the destination:

a) Has a lack of electricity and ICT infrastructure. Interruptions in services occur frequently
b) Needs to improve the quality of either ICT or power infrastructure
c) Has enough power and ICT infrastructures for the current demand. Some interruptions occur occasionally
d) Has very good power and ICT infrastructures (mobile and fibre networks), enabling opportunities for new business and/or expansion

A Tourism Action Plan is essential in case of an extreme natural event such as flood, storm surges, thunderstorms, heatwaves etc. Does this business/company have an action plan?

a) No
b) Yes, but it requires the company to build infrastructure **AND** to train staff
c) Yes, but it requires the company to build infrastructure **OR** to train staff
d) Yes, the infrastructure required is built and staff are trained and prepared for expected hazards

In case of 50% slump for 12 months in destination's visitor numbers, would you have another source or potential job to keep income coming and compensate for such loss?

a) No
b) Yes, please give details

Business type: (restaurant, accommodation, travel agency, park, etc.)

Socioeconomic information

1) Age
2) Gender
3) Income
4) Education level