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REVIEW ARTICLE

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Climate change, coastal tourism, and impact chains – a literature review

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ABSTRACT

Climate change impacts tourism, since both supply and demand of tourism services depend on the quality and the management of a set of environmental attributes. This paper critically reviews the empirical evidence in the literature of the last twenty years (2000–2019), by identifying the potential impacts of climate change in coastal and maritime destinations. The concept of Impact Chains is the methodological framework through which the literature is systematically selected, classified and assessed.

A great heterogeneity of results is found, with estimates of physical and socio-economic impacts of climate change differing across destinations and methodologies. Moreover, the majority of recent studies mainly deals with only a few of the most important impacts, hence future research should be re-directed to overlooked indicators and relationships, which are key for designing effective climate policies at tourism destinations.

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Climate change; impact chains; tourism; literature review; meta-evaluation

1. Introduction

The main goal of this paper is to gather and critically examine empirical evidence on how Climate Change (CC) impacts coastal and maritime tourism. This is done through a review and meta-evaluation of the literature of the last twenty years (2000–2019).

Many works investigate the socioeconomic impacts of CC on tourism, but the strong heterogeneity in their methodology, focus, and area of investigation makes it hard to achieve a comprehensive picture of the complex relationship at play (Amelung et al., 2007; Ciscar et al., 2011; Hall et al., 2012). Being a multidisciplinary topic, researchers from different fields bring their own conceptual models to the study of vulnerability and adaptation of tourism to CC, models which often address similar problems but using different lenses. In other words, there is still a lack of '*common language so that climate change research can move forward in a way that integrates different traditions in a coherent yet flexible fashion, allowing researchers to assess vulnerability and the potential for adaptation in a wide variety of different contexts*' (Brooks, 2003, p. 2).

As 'common language' we propose the Impact Chains (IC) conceptual architecture, widely employed by the Intergovernmental Panel on Climate Change, IPCC[1] (2012, 2014b). The IC framework pivots around the notion of risk as the result of the complex interaction between hazards,

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exposure of natural, social, and economic subsystems, and the degree of their vulnerability to climate shocks (Brooks, 2003; Brooks et al., 2005).

Publications are hence selected, classified, and critically analysed according to a set of IC that have been developed for the context of coastal and maritime tourism. Such framework constitutes the methodological approach to the review, thus allowing the assessment of publications from a multidisciplinary perspective and the identification of the research areas that have not been sufficiently covered. Not only this approach allows to delimitate the scope of the search, but also to assess the contribution of different academic disciplines (climatology, economics, etc.) to the construction of a holistic base of knowledge. The IC tool is considered the most appropriate appraisal method for understanding and communicating climate change effects in any sector, thus it helps strengthen the science-policy interface and identifies important areas where the efficient and practical design of climate policies can be supported (Abadie, 2018; Jones et al., 2014; Tangney, 2019). Therefore, as the set of IC built in this study was defined through a participatory method involving policy-makers, practitioners and other stakeholders, any lack of publications in specific areas (IC) is, in a way, a measure of where policy design asks for the support of scientific research.

The paper does not consider CC impacts on all tourism activities, a burdensome task, but only focuses on coastal and maritime tourism. This is done for two reasons: one, these destinations are mainly developed around the 3S (sea, sun & sand), arguably the most important tourism segment globally, and a one heavily depending on the quality of environmental services; two, most of these destinations are fragile ecosystems (e.g. islands) where CC are likely to produce relevant physical and economic consequences (Nurse et al., 2014).[2] Accordingly, we adapt the general IC framework to the specific risks stemming from CC hazards faced by coastal and marine tourism. These risks affect both the value of the recreational experience and the decision-making process of tourists before, during and after visiting the destination: the literature is hence classified and systematically reviewed according to the IC analysed by each paper.

In a nutshell, the novelties of the paper are, on the one hand, to critically classify and present recent findings and contributions on the link between CC and coastal and maritime tourism. The use of the IC methodological approach, in this sense, constitutes an advancement with respect to the few existing reviews of the literature (Becken, 2010; Fang et al., 2018; Kaján & Saarinen, 2013; Steiger et al., 2019), and could be easily adapted to other types of destinations (art cities, mountain resorts, etc.). On the other hand, this approach easily identifies under-investigated research areas on which to focus in the near future.

The paper is structured as follows. Section 2 presents the methodology, including a general introduction of IC and the identification of the relevant impacts for coastal tourism. In this section, the process of selection and classification of the literature is also discussed. Section 3 focuses on the meta-evaluation of the literature and considers both the biophysical and the socioeconomic impacts of CC on coastal and maritime destinations. Finally, Section 4 discusses and concludes.

2. Methodology

Systematic reviews and meta-evaluations are often known as research syntheses (Weed, 2006). The systematic review is widespread in the fields of medicine and psychology, to ensure that treatments, interventions, and initiatives are based on 'best evidence' (Davies et al., 1999); it is also used to assess the nature and extent of knowledge in any other area (Marasco et al., 2018; Papathanassis & Beckmann, 2011). It consists of a comprehensive search of relevant studies on a specific topic; studies are appraised and summarized according to a pre-determined explicit method (Klassen et al., 1998). Criteria for collecting the studies have to be explicit from the outset, and the scope of the review should be clearly delimited (Weed, 2006).

Given that the prefix 'meta' literally means 'beyond' or 'across', the term 'meta-evaluation' or 'meta-analysis' usually refers to the evaluation of a number of studies, with their research questions, the appropriateness of the methods used, and their contribution to the body of knowledge in the

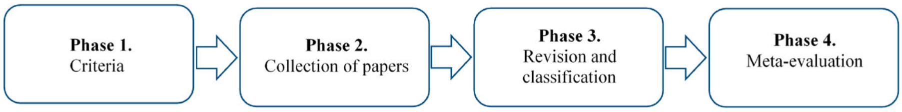

Figure 1.

area (Scott-Little et al., 2002; Weed, 2006; Woodside & Sakai, 2001). Following Finn et al. (1997), a qualitative-oriented meta-evaluation is employed, which is more interpretive (Paterson et al., 2001; Stepchenkova & Mills, 2010). Next sub-sections are dedicated to describing the theoretical foundations that support the IC application to the selection criteria, and the systematic review process, which is described in Figure 1.

2.1. The concept of impact chains

Tourism long-term sustainability depends on the preservation and enhancement of its environment. Climate change affects several services that ecosystems provide to tourism (Cheer & Lew, 2017; Franzoni, 2015; Kaján et al., 2015). For example, more frequent and severe heatwaves or beach availability reduction due to sea level rise influence the value of the recreational experience at the destination, hence affecting tourism demand and expenditure. The systematic assessment of the complex relationship between climate hazards, risks, tourism demand, and tourism experience value requires the accurate identification of a conceptual framework through which analysing the literature: the Impact Chains (IC).

The concept of IC was introduced by Isoard et al. (2008) and Schneiderbauer et al. (2013), then 'catalyzed' by the German cooperation (GIZ) in the Vulnerability Sourcebook (Fritzsche et al., 2014) and since then widely used as a climate risk assessment method at the global scale (UNDP, World Bank, Horizon 2020, etc.), as well as at local, regional or national level. Under this approach, risk is defined as '*the potential, when the outcome is uncertain, for adverse consequences on lives, livelihoods, health, ecosystems and species, economic, social and cultural assets, services (including environmental services) and infrastructure*' (IPCC, 2014a, p. 127). Thus, risk assessment concerns the interaction of climatic, environmental and human factors that can lead to impacts and disasters, the options for managing the underlying risks, and the important role that non-climatic factors play in determining impacts (Birkmann, 2006; Turner et al., 2003).

IC can be both a technical tool integrating quantitative and qualitative results from different disciplines, and a participatory tool, allowing a better understanding and dialogue with communities, policy makers and stakeholders. IC have the capacity to be cross sectoral and cross scales and allow to aggregate or downscale risks and compare sectors. This methodology has been employed to analyze climate-related risks for agriculture, food production and consumption, terrestrial and marine biodiversity (Dickinson et al., 2014; Jacxsens et al., 2010; Mach et al., 2016), and represents the main application to support the design of disaster risk management and adaptation strategies in urban and coastal cities (Abadie, 2018). It is considered the most appropriate appraisal method for understanding and communicating climate change effects on any sector, thus facilitating policy design (Jones et al., 2014; Tangney, 2019): indeed, this confirms the validity of this approach for tourism related studies.

The IC looks like a diagram (Schneiderbauer et al., 2013), which summarizes the relationships between different climate shocks, ecosystem services and economic activities under study, taking into account exposure (to climate parameters), sensitivity (related to physical and socio-economic features of the destination), and adaptive capacity. According to the Glossary of the IPCC Fifth and Fourth Assessment Report (IPCC, 2014a; IPCC, 2007), the components of the IC (which are reported in Figure 2) can be defined as follows:

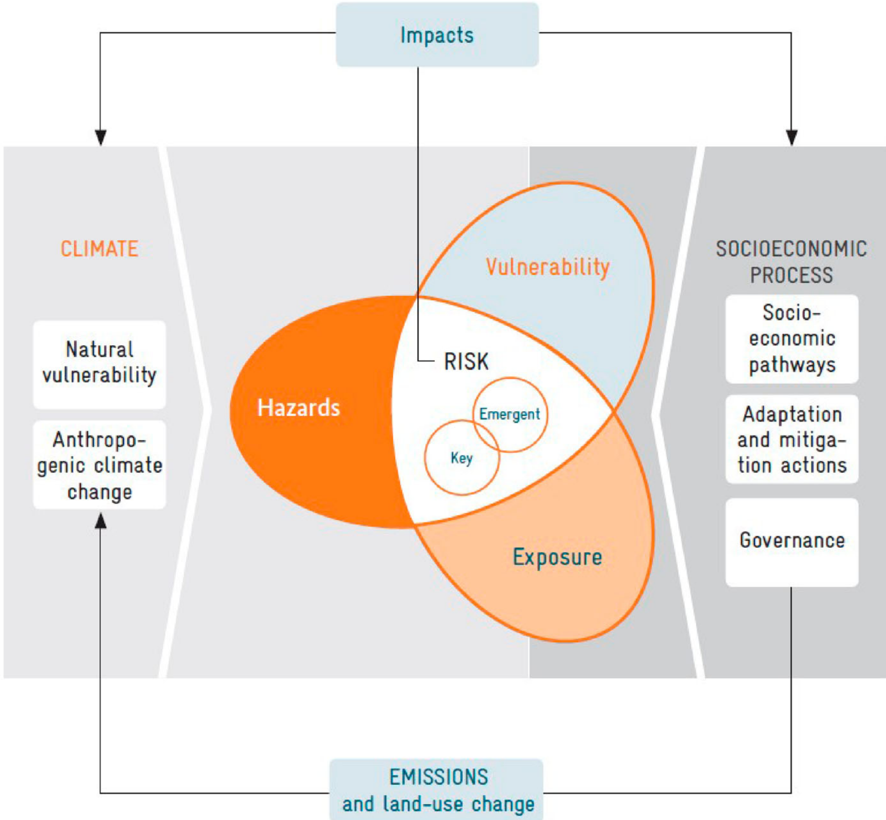

Figure 2.

- Hazard is the potential occurrence of a climate-related physical event or trend, or its physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources (Brooks, 2003; Brooks et al., 2005).
- Exposure is the presence of people, livelihoods, species, ecosystems, environmental functions, services, infrastructures, economic, social, or cultural assets in places and settings that could be adversely affected (Dickinson et al., 2014). The degree of exposure can be expressed by absolute numbers, densities, or proportions of the elements at risk (e.g. population density in an area affected by drought).
- Vulnerability is the propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt (Ford et al., 2010; Füssel, 2007). Sensitivity may include physical attributes of a system (e.g. building material of houses, type of soil in agriculture fields), social, economic, and cultural attributes (e.g. age distribution, income distribution). Adaptive capacity refers to the ability of societies and communities to prepare for and respond to current and future climate impacts.
- Risk is the potential climate-related consequence (climate impact) for something of socio-economical value (assets, people, ecosystem, culture, etc.) (Brooks, 2003; Dickinson et al., 2014; Tangney, 2019).
- Impacts are the effects on natural and human systems, on lives, livelihoods, health, ecosystems, economies, societies, cultures, services, and infrastructure due to the interaction of CC or

hazardous climate events occurring within a specific time period, given the level of vulnerability of an exposed society or system (Nguyen et al., 2016; Schneiderbauer et al., 2013).

2.2. Selection criteria

The first step of the review procedure presented in Figure 1 consisted of establishing the selection criteria. As regards adaptation of the general IC framework described in the previous sub-section to the needs of coastal tourism, an expert-assisted process was used, pivoting around the concept of tourist experience value (Prebensen et al., 2014). This process stressed that three main categories of IC, summarizing all the interactions that tourists can experience at destination, were relevant for the coastal and maritime tourism sector: (i) the quality of the natural environment; (ii) the quality of infrastructure and facilities, and (iii) the quality of human being comfort. Changes in these attributes due to CC can drive to a loss in the tourist experience value.

From the demand perspective, the IC framework is consistent with the *lancasterian* approach (Lancaster, 1971), based on the idea that marketed products are defined by a combination of characteristics which attract consumers. Tourists who travel to destinations purchase goods and services because they want to access, in desired quantities and combinations, services provided by the ecosystems at destinations (Hoa et al., 2018; Seddighi & Theocharous, 2002). Climate induced changes would modify the ecosystem services and hence the value of the tourist experience. Impacts can be observed either as market (change in tourism flows or in tourism spending) or as non-market values (well-being). Demand modelling of these decisions can be approached via discrete choice models (Ben-Akiva & Lerman, 1985; Louviere et al., 2000; Papatheodorou, 2001).

The three categories were further broken down into nine IC, selected through the assistance of external experts' views and opinions. Twelve focus groups were organized, which saw the participation of more than one hundred of climatologists, environmental economists, geographers, high-level policy makers and practitioners of the tourism sector of ten different destinations. The final set of IC aimed at defining measurable risks, although built for European coastal and island destinations, can easily be applied to assess and quantify many other maritime tourism sites. The three areas and the nine selected IC were defined as follows:

1. Loss of tourist experience value in the destination due to changes in *environmental attributes*.

1.1. Loss of attractiveness of marine environments due to loss of species, increase of exotic invasive species or degradation of landscape.

1.2. Loss of attractiveness and comfort due to beach availability reduction.

1.3. Loss of attractiveness due to increased danger of forest fires in tourism areas.

1.4. Loss of attractiveness of land environments due to loss of species, increase of exotic invasive species or degradation of landscape.

2. Loss of tourist experience value in the destination due to changes in *human being comfort (or health)*.

2.1. Loss of comfort due to increase of thermal stress and heat waves.

2.2. Increase of health issues due to emergent diseases.

3. Loss of tourist experience value in the destination due to the change in the *quality of infrastructure and facilities*.

3.1. Increase of damages to infrastructures and facilities (accommodation, promenades, water treatment system, etc.).

3.2. Decrease of available domestic water for the tourism industry.

3.3. Loss of attractiveness due to loss of cultural heritage (monuments, gastronomy, etc.).

Figure 3 represents an integration of the nine selected IC. Each IC selected for this work is represented by a subset of elements of the generic IC and is reported in the Appendix, Figures A1–A9. Due to the intrinsic complexity of tourism destinations, risks must be formulated as the combination of many hazards and, at the same time, a single hazard may be linked to more than one risk.

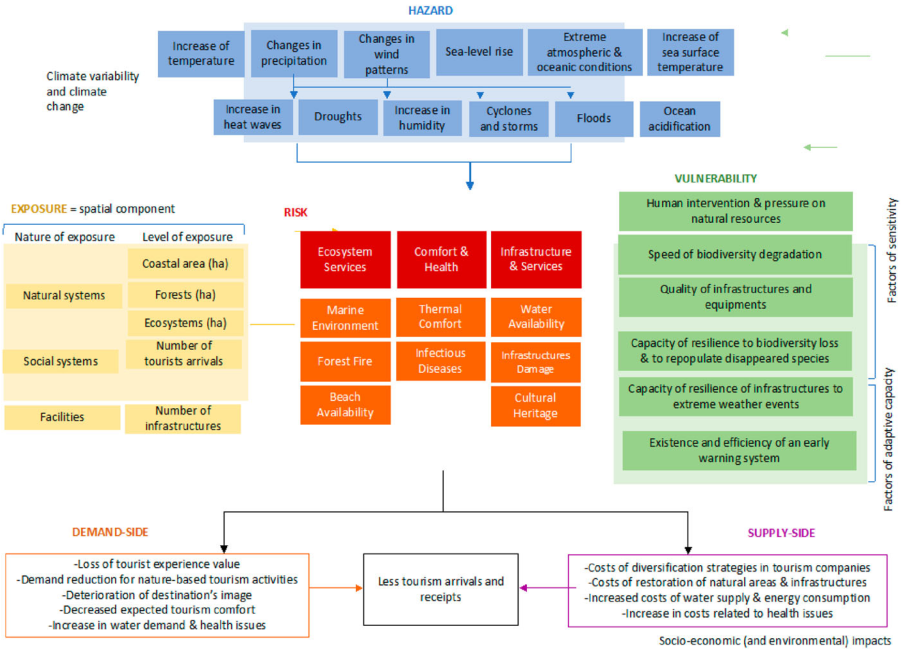

Figure 3.

CC related risks at destinations are hence presented as having a multi-hazard origin (Nguyen et al., 2016). For example, the risk of a diminished destination competitiveness due to beach surface loss arises both from sea level rise and from higher erosion due to the increased energy of sea water beating the shoreline. In the case of ecosystem services, potential climate hazards affect different types of both marine and land environments. Regarding comfort and health, potential risks of both thermal stress and changes in the likelihood of being affected by emergent diseases have been considered important. With respect to infrastructures and services, apart from damages to infrastructures and to the cultural heritage, the availability of water supply has also been identified as an important risk.

The set of identified climatic hazards are in line with the existing literature and with the IPCC reports. In particular, heat waves, droughts, floods, storms, and other extreme atmospheric events often have a sharp and important impact on biodiversity, society, and infrastructures, due to their immediate destructive effects. Other climate hazards, such as the increase in average temperatures, changes in precipitation and wind patterns, sea level rise and ocean acidification are less noticeable since their impact is progressive but, at the same time, very relevant because of their influence on extreme hazards and for their effect on ecosystems and habitats.

As regards the selection of publications, all articles that touched some piece of any of the nine ICs were included. This means that not only we selected papers covering the whole IC (which are a few, indeed), but we also and mainly considered papers that looked at physical impacts, vulnerability assessment, or economic impacts only. We did not consider papers not covering any of the selected IC, even if they fall under CC impact analysis for tourism. Articles come from various sources: firstly, refereed journal articles indexed in the databases Journal Citation Reports and Scopus were considered (Hall, 2011). In addition, policy papers and official reports from regional agencies and international organizations were also included. This heterogeneity in searched elements was justified by the need to 'bridge' purely academic studies with topics of interest for practitioners and for policy makers that are not covered by academic research. A quality criteria for the selection was not used in this review: limiting the research to refereed journal articles implies some form of quality control that is in contrast with one of the goals of the meta-evaluation procedure, which is to assess the quality of the research (Zhang et al., 2014). The period was delimited in twenty years (publications from 2000 to 2019).

2.3. Collection and analysis

The second step of the process described in Figure 1 was the collection of papers, searched through the title or the abstract. A non-exhaustive list of search keywords included: climate change, climate impacts, climate risk, tourist perception, risk perception, environmental management, environmental technical change, impact assessment, beach loss, beach surface availability, beach erosion, tourist behaviour, willingness to pay, tourism expenditure, destination choice, etc. At this stage, a speed reading (abstract, first paragraph, and as much text from relevant sections as needed) was necessary to classify the articles according to the following dimensions: research focus, theoretical framework, conceptualization, geographical scope, methodology employed, results, policy implications. This step allowed to obtain a vast group of publications. The systematic review took place from August 2018 to August 2019, with a full reading of articles and their classification. An update was later conducted in July 2020.

Tabulation was carried out following guidance from previous research (Hunter et al., 1982; Paterson et al., 2001; Pike, 2002; Stepchenkova & Mills, 2010). If an article sought to develop an in-depth understanding of concepts by building on existing knowledge, the article was considered conceptual. Conversely, if an article tested original research or theory by employing human subjects or textual samples and statistical techniques, it was classified as empirical. The articles that were exclusively conceptual were discarded. Those empirical and conceptual/empirical articles were further classified into quantitative versus qualitative streams based on predominant methodologies. Methods and models employed were also identified, leading to a new categorization of the studies. Other categories were created utilizing the IC tool, according to climate hazards being studied, vulnerability and exposure aspects (if relevant), and the social and economic impacts analysed, allowing the final integration of each paper within the IC structure.

The categorization was carried out independently by three different authors to avoid discretional bias, and cross-checking of information was periodically conducted through internal meetings. A high concordance level was obtained, around 97% of total items. Finally, the process was checked by four experts of the European Commission, as part of the quality review process established by the European Union (funder of this research), and one doctoral researcher specialized in climate change and tourism.

The selection procedure resulted in a sample of 109 publications (Table 1). Papers were published more frequently in Hospitality and Tourism journals (38%) and in Environment and Ecological journals (22%). Publications addressing tourists' valuation and behaviour (32%), and economic impacts of CC and related policies (33%) were the most frequent. Studies on CC impacts have been gaining relevance in the last few years, as only 38 were published in the first decade of the new millennium, while the remaining 71 in the 2010–2019 period.

3. The meta-evaluation: findings and discussion

Evidence in the literature is fragmented, focusing either on the impacts of different hazards on ecosystem services and infrastructures, or on tourists' behaviour, or on the economic valuation of changes in environmental attributes. Hence, a systematic assessment of the whole IC of CC for tourism is missing. This is unsurprising given that the study of the full chain of interconnections from hazards to physical to economic impacts requires multidisciplinary and multifield analysis. Only a few studies follow an integrated approach to determine the economic impact of the hazard on the final risks. Therefore, we include and summarize available evidence from various fields and disciplines which fit separate elements (e.g. physical impacts, economic impacts, etc) of

Table 1. Number of publications per year and research field (2000–2019).

Subject	Year	Count	Year	Count
Physical impacts on the natural and human-made environments, relevant for the tourism activity (i.e. beach erosion, coastal infrastructures, corals reefs, land habitats, etc.) N=25	2000	1	2011	1
	2002	1	2012	2
	2008	2	2013	3
	2009	1	2014	2
			2017	1
			2018	2
			2019	9
Tourists' valuation and behaviour under CC impacts and related policies (i.e. destination choice, expenditure, repetition of visit, willingness to pay) N=35	2001	1	2011	2
	2005	3	2012	3
	2006	4	2013	6
	2007	1	2014	4
	2008	2	2015	3
	2009	2	2017	1
			2018	1
			2019	2
Tourists' comfort and thermal comfort indices (i.e. IPCC scenarios, physiological equivalent temperature, Holiday Climate Index) N=14	2000	1	2011	1
	2006	1	2015	1
	2007	1	2016	2
	2008	3	2019	2
	2009	1		
	2010	1		
Economic impacts (i.e. costs of adaptation, changes in tourism arrivals and receipts, effects on GDP) N=36	2001	2	2012	3
	2003	1	2013	2
	2004	2	2014	1
	2005	1	2015	1
	2007	1	2016	3
	2008	4	2017	3
	2009	2	2019	2
	2010	7		
TOTAL = 109 publications				

the ICs described in Section 2, thus identifying gaps in the existing literature to point out suggestions for future research.

In the meta-evaluation carried out in this section each IC is assigned to a specific sub-section (from 3.1.1 to 3.3.3). For each IC we focus on the different levels, moving from hazards to physical impacts, and to socio-economic demand/supply-side outcomes according to the reported evidence. Findings are also summarized, for the readers' convenience, in nine corresponding tables (from Table 2 to 10, one for each IC) where more information about the quantitative evidence is reported. IC are accompanied by a corresponding graphic representation, that can be found in the Appendix (Figures A1–A9).

3.1. Loss of tourist experience value due to changes in environmental attributes

3.1.1. Loss of attractiveness of marine environments due to loss of species, increase of exotic invasive species or degradation of landscape

Shifts in climatic attributes of destinations may result in spreading of invasive and dangerous species with consequent losses of marine and coastal habitat, also affecting tourists' well-being, choices, and expenditure decisions (Nilsson & Gössling, 2013; Nunes et al., 2015). The loss of marine habitats is amongst the indirect environmental effects of CC that may have the most profound implications on the destination's attractiveness and degradation of landscapes, especially if wildlife is the main reason for visiting. A summary of the studies analysing this IC is presented in Table 2.

As regards marine environments there is a substantial bias in the literature towards studying coral reefs (Coghlan & Prideaux, 2009; Hall, 2001; Marshall et al., 2011), as they represent an important attraction for tourists but, at the same time, they are also very delicate ecosystems deeply affected by CC. Regarding physical impacts, the increase of oceanic waters temperature causes

Table 2. Summary of impacts corresponding to *Loss of attractiveness of marine environments due to loss of species, increase of exotic invasive species or degradation of landscape.*

Impact Studied	Reference	Results
Physical impact on biodiversity and ecosystems	Bythell et al. (2000)	Higher frequency of extreme events (cyclones, hurricanes or typhoons) due to CC does not allow the natural recovery of reefs (even if their level of resilience is high).
	Galbraith et al. (2002)	2°C global warming and inundation of low-lying coasts could cause loss of 20–70% of shorebirds habitats (US).
	Poloczanska et al. (2009)	SLR and increased intensity of storms would have a negative impact on turtle nesting beaches. However, seawater temperature rise may increase food availability for them.
	Marshall et al. (2011)	Increase of oceanic water temperature causes mass coral bleaching that damages the reefs; ocean acidification endangers their flora and fauna.
	Scott et al. (2012a)	Coral bleaching is mainly due to temperature change and ocean acidification.
	Scott et al. (2012b)	Temperature change and ocean acidification is due to 30% of total emitted anthropogenic CO2 in ocean waters (IPCC, 2014a; IPCC, 2014b) and impact the reproductive and physiological activity of marine creatures, increasing their vulnerability.
	IPCC AR5 (2014a)	Numerous species may extinguish because of climate change and the other modifications that are affecting their environment.
	Cuttler et al. (2018)	Coral reefs are not only an important part of marine ecosystem and a tourist attraction, but also a shield that protects beaches and coasts from erosion.
	Hongo et al. (2018)	Impact of projections of SLR and tropical cyclones on beach erosion: healthy reefs can reduce wave heights by up to 0.44 m. A reduction by 0.1 m would be sufficient to decrease risk of coastal and infrastructural damages.
Tourists' valuation and behaviour	Uyarra et al. (2005)	>80% of tourists unwilling to pay the same holiday price in the event of coral bleaching as result of elevated sea surface temperatures and sea level rise. (Bonaire and Barbados).
	Parsons and Thur (2008)	Drop in quality of reefs results in per-capita spending decrease of $45-$192 (Bonaire).
	Kragt et al. (2009)	Great Barrier Reef deterioration would lead to total expenditure decrease from A$250 million to A$50 million per year.
	Rolfe and Windle (2012)	Average WTP for policies to improve the Great Barrier Reef is $21.68 (AUD) per annum for five years.
	Cheablam et al. (2013)	Although coral has been severely degraded, >50% of tourists are willing to revisit the park; 2/3 were satisfied with quality of tourism activities (Mu Ko Surin National Park).
	Tseng et al. (2015)	Average WTP to protect and restore coral reef potential is $35.75 (USD) (Taiwan).
	Nunes et al. (2015)	Average WTP for a decrease of jelly fish blooms is €3.20 per beach visit. Gains associated with reduction of jelly fish amount to €422.57 million (Catalonia).
	McClenachan et al. (2018)	WTP is US $5.61/ year for a 10% increase in coral coverage and biodiversity (Okinawa, Japan).
	Schuhmann et al. (2019)	Tourists' willingness to pay a fee for coastal and marine conservation in Barbados ranges from US$36 to US$52 per visit.
Economic impacts	Stolte et al. (2003)	Impacts of harmful algae blooms on public health, commercial fisheries, recreation and tourism, and monitoring and management costs are estimated to be: €181 million (France); €178 m. (Spain); €115 m. (Italy).
	Payet and Obura (2004)	In the western Indian Ocean, where 30% of corals loss led to a considerable decrease in visitors, economic losses amount to almost US$18 million.
	Cesar et al. (2004); Burke et al. (2008)	Total coral reef-associated tourism amounts to 21% of GDP (St. Lucia) and to 40% of GDP (Tobago).
	Brander et al. (2012)	Meta-analysis for 79 countries. Annual damage to coral reefs caused by ocean acidification will reach 0.14–0.18% of global GDP in 2100.
	Zeppel (2012)	Climate change results in increased awareness of tourists and business, leading to increased costs of preservation and restoration of marine coastal flora and fauna.
	Bayraktarov et al. (2016)	Cost of restoration or rehabilitation projects vary significantly, depending on location, type of ecosystem and executing actor. Projects in developing countries are 30 times less expensive; coral

(*Continued*)

Table 2. Continued.

Impact Studied	Reference	Results
		reefs and seagrass are among the most expensive ecosystems to restore. Median and average cost for restoration of one hectare of marine coastal habitat were between $80,000-$1,600,000 (Europe, US, Australia).

mass coral bleaching that damages the reefs, while acidification of the oceans endangers their flora and fauna (Marshall et al., 2011; Scott et al., 2012b). Another risk factor is the increased intensity and frequency of extreme events. Although it is acknowledged that corals are endowed with high level of resilience and can naturally recover from cyclones, hurricanes or typhoons (Bythell et al., 2000), when these extreme events become more frequent, the reefs are not able to fully regrow, especially if other climatic changes are at place. Furthermore, destruction of corals due to the storms may trigger the invasion of algae (Welsh, 1983), which may affect tourist demand, as shown in Nilsson and Gössling (2013). Also note that not only coral reefs are an important component of marine ecosystems and a tourism attraction, but also a shield that protects beaches and coasts from erosion (Cuttler et al., 2018). A study by Hongo et al. (2018) has incorporated projections of both sea level rise (SLR) and tropical cyclones to simulate impacts on beach erosion under two scenarios: a degraded reef and a healthy reef. Results show that healthy reefs can significantly reduce wave heights by up to 0.44 m, while a reduction by only 0.1 m would already be sufficient to decrease the risks of coastal and infrastructural damages. Hence, these studies show how different physical impacts are strongly interconnected.

Such physical changes have impacts on the tourism industry, particularly where the natural attributes are of high value for tourists (e.g. Burke et al. (2008) estimate that tourism associated with coral reef amounts to 21% of GDP for St. Lucia and to 40% of GDP for Tobago), thus potentially having profound socio-economic impacts. It has been proved that biodiversity loss results in a lower probability of revisiting the destination (Parsons & Thur, 2008; Uyarra et al., 2005), with consequent economic costs (Cesar et al., 2004; Kragt et al., 2009; Parsons & Thur, 2008; Payet & Obura, 2004; Scott et al., 2012b). At the same time, the impact is case-specific: Cheablam et al. (2013) study the case of massive coral bleaching in Mu Ko Surin National Park, Thailand. Despite tourists strongly agree that coral has severely degraded, more than half of respondents were willing to revisit the park, and two-thirds of the respondents were satisfied with the overall quality of the tourism experience. On the other hand, research shows that visitors are willing to pay for coral reefs restoration and preservation (McClenachan et al., 2018; Rolfe & Windle, 2012; Schuhmann et al., 2019; Tseng et al., 2015).

As mentioned before, linking together both physical and economic impacts is seldom accomplished. For this IC, a notable exception is a study by Brander et al. (2012) who assess the economic impact of ocean acidification on coral reefs under four IPCC scenarios. They predict that in 2100 the loss caused by coral reefs degradation will amount to 0.14–0.18% of the global GDP.

Other species of marine and coastal habitat are also at risk. Assuming 2°C global warming and consequent inundation of low-lying coasts for shorebirds in the US, the projected loss of habitat ranges from 20 to 70%, with most vulnerable sites being those where the current coastline is unable to move inland because of steep topography or coastal defence structures such as sea walls. (Galbraith et al., 2002). For certain species, however, the impact may either be positive or negative depending on the exact CC scenario and on specific physical impacts: SLR and increased intensity of storms would have a negative impact on turtle nesting beaches, while seawater temperature rise may result in increased food availability for the same animals (Poloczanska et al., 2009).

These findings show that CC increases awareness of both tourists and businesses (Zeppel, 2012), and leads to higher efforts of preservation and restoration of marine and coastal flora and fauna from the supply-side (Stolte et al., 2003). According to Bayraktarov et al. (2016), costs vary significantly over many dimensions, depending on the location (in emerging economies, costs are up to 30 times less expensive), type of ecosystem to restore (coral reefs and seagrass are among the most expensive ecosystems to restore), and executing actor (public vs. private). The average reported cost for restoration of one hectare of marine coastal habitat ranges between US$80,000 and US $1,600,000 in 2010, while the authors suggest that the median cost could be about two times higher (Bayraktarov et al., 2016).

To the best of our knowledge, apart from coral reefs, in the last twenty years no studies have focused on the full chain from physical impacts, starting with water heating and ocean acidification caused by CC, through the effect on species abundance and density, reduction in biomass and biodiversity, water turbidity, presence of dead seagrass on beaches, to the final economic impacts. These effects are of great importance for coastal and maritime destinations, as sunbathing, snorkelling, diving and glass-bottom boating are among the most frequent tourism activities. Hence, this topic should constitute a priority for future research.

3.1.2. Loss of attractiveness and comfort due to beach availability reduction

Concerning beach availability, the most important CC hazards in coastal and maritime areas are sea level rise (SLR) and higher frequency of extreme events (storms, high waves, etc.). They produce physical impacts, such as beach surface reduction, which in turn affect tourism activity from both demand and supply sides. A summary of papers analysing the risk of loss of attractiveness and comfort due to beach availability reduction is presented in Table 3.

As regards physical impacts, a huge body of literature provides evidence on potential future effects of SLR on coastal retreat: while generally the impact is negative, various factors make some coastlines more vulnerable to SLR than others, resulting in considerable heterogeneity of projected impacts, driven by the difference of underlying CC scenarios, even within the same destination (Antonioli et al., 2017; Enríquez et al., 2017; Snoussi et al., 2008). Despite this drawback, the very nature of SLR physical impacts allows to link them quite easily to the supply side of the socio-economic impacts, with effects on properties, infrastructure, and facilities. Therefore, we document a higher degree of coherence between physical and economic impacts for this IC as compared to others.

Overall, the literature finds high vulnerability of hotel infrastructure to flooding (Lithgow et al., 2019), and significant costs for the hotel industry (Wielgus et al., 2010). Importantly, apart from direct impacts of SLR on hotel properties and related facilities (inundation), the indirect impact (beach erosion) is at least as relevant driver of total losses (Scott et al., 2012a). Interestingly, this stream of literature is biased towards assessing the impacts on Caribbean destinations. While most of the studies tend to project severe consequences of SLR on coastal infrastructures as well as overall public losses (Bitan & Zviely, 2019), some other suggest that the overall impact on the tourism industry would be moderate. Bigano et al. (2008) estimate that 25 cm. of SLR projected by 2050 would lead to a GDP loss ranging from 0.1% in South East Asia to almost no loss in Canada, while redistribution of tourist flows would correspond to GDP losses ranging from 0.5% in Small Island States to 0.0004% in Canada. Therefore, the study highlights that both SLR and the redistribution of tourism flows would impact differently in different parts of the world, which justify more academic attention on the issue.

On the demand side of the socio-economic impacts, beach surface reduction is found to negatively impact the destination image, decreasing tourism arrivals and receipts (Raybould et al., 2013; Scott et al., 2012a; Uyarra et al., 2005). Consequently, adaptation initiatives such as beach protection and artificial beach nourishment are implemented by several countries (Mycoo & Chadwick, 2012). Such measures are obviously costly, with costs varying considerably depending on the region, but ignoring them may lead to much higher SLR-induced losses (Darwin & Tol, 2001). At the same time, many tourists claim to accept coastal protection measures (Atzori et al., 2018) and are aware of protection importance, adapting their attitudes even if they express concerns from an aesthetical perspective (Buzinde et al., 2010). Not surprisingly, numerous studies focus on estimating the willingness to pay for beach protection measures (Castaño-Isaza et al., 2015; Kontogianni et al., 2014; Koutrakis et al., 2011; Rulleau & Rey-Valette, 2013).

Table 3. Summary of impacts corresponding to *Loss of attractiveness and comfort due to beach availability reduction.*

Impact Studied	Reference	Results
Beach erosion and damage to coastal infrastructure	Schleupner (2008)	25 cm SLR poses a risk on 87% of beaches used for tourism (Martinique).
	Snoussi et al. (2008)	24% of land loss in the case of 2 m inundation (*best case*); 59% of land loss if 7 m inundation (*worst case*) (Moroccan coasts).
	Scott et al. (2012a)	1 m of SLR will result in 29% of resort properties partially or fully affected; indirectly affected 60% of resort properties. Uneven spread: 50% of loss burden lying on 5 countries. (Caribbean islands).
	Sagoe-Addy and Addo (2013)	13 tourism facilities may suffer from SLR impacts; 31% likely to be fully damaged (Accra, Ghana).
	Antonioli et al. (2017)	Projections of SLR for 2100: 526–1010 mm for IPCC scenario and 1430 cm for Rahmstorf scenario will result in 5500 km^2 inundated (Italian coastal regions).
	Enríquez et al. (2017)	As a result of sea level rise, beaches would suffer a coastal retreat between 7 and up to 50 m, depending on the beach and on the RCP scenario, equivalent to half of the present-day aerial beach surface (Balearic Islands).
	Lithgow et al. (2019)	30% of tourist destinations are exposed to flooding; 62% of total study area had a moderate to severe degree of coastal squeeze, and 66% of the hotels are in squeezed beaches (Mexican Gulf of Mexico & Mexican Caribbean).
Tourists' valuation and behaviour	Uyarra et al. (2005)	77% of tourists unwilling to return in case of beach surface reduction (Barbados).
	Koutrakis et al. (2011)	In the context of France, Greece and Italy average visitors' WTP for beach defense amounts to €0.5–1.49 per day.
	Raybould et al. (2013)	17–23% of tourists would opt for alternative destinations under different beach erosion scenarios (Australia).
	Nilsson and Gössling (2013)	Algae bloom affects tourist demand: >75% consider algae bloom as something negative (health hazard, threat to bathing, aesthetic problem) and reduce visitor satisfaction. <25% have been affected by the algae: 81% could not take a swim and 40% changed activities; 17% shortened their stay and moved to another holiday area; 8% cancelled their holiday.
	Rulleau and Rey-Valette (2013)	Average WTP for beach protection measures is €36.4 per household per year (French Mediterranean).
	Kontogianni et al. (2014)	WTP for adaptation measures for loss of beach surface in Greece €13.2–16.4 (annual tax) per household.
	Castaño-Isaza et al. (2015)	Tourists' experience value for San Andres Island beaches implies an overall WTP to be US$ 997,468 annually.
Economic impacts (including tourists flows and world economy)	Darwin and Tol (2001)	If no protection measures are implemented, 0.5 m of SLR in 2100 would have an annual cost of $7billions in Europe and $36billions in Asian regions. The adoption of an optimal protection package would cost $10.5billions, globally.
	Uyarra et al. (2005)	Tourism revenues decrease by 46% because of less tourism arrivals due to beach reduction (Barbados).
	Bigano et al. (2008)	25 cm of SLR projected by 2050 would lead to GDP loss of 0.1% in South East Asia; no loss in Canada. Redistribution of tourist flows would produce GDP losses from 0.5% in Small Island States to 0.0004% in Canada.
	Wielgus et al. (2010)	Hedonic prices model estimates tha over the next 10 years beach erosion may induce losses of $52–$100 million for the hotel industry (Dominican Republic).
	Ghartey (2013)	Increased number of hurricanes may cause a fall in the exchange rate and a decrease in tourism arrivals in the short term, with a negative impact on tourists' expenditures in the long run (Jamaica).
	Raybould et al. (2013)	Drop of revenues around $20-$56million per year because of less tourism arrivals due to beach reduction (Australia).
	NOAA (2016)	The immediate economic impacts of events such as El Niño can be quite considerable, reaching US$11.5 billion globally.
	Siddiqui & Imran (2019)	Climate effects have been discussed for different case studies and regions, in terms of tourism arrivals and receipts.
	Bitan and Zviely (2019)	Economic losses from public bathing beaches in the Mediterranean coast of Israel: overall, annual losses of public benefits are estimated to be NIS 122 million ($31 million) and NIS 416 million ($104 million) for values of 0.2 and 1.0 m SLR respectively.

Beach reduction also stems from extreme events, and the literature on their physical dynamics generally finds that their frequency and intensity have been increasing over time. Wave height and other parameters of storminess, which are found to have risen over the last decades, are of interest for maritime tourism. Specifically, there is a significant trend in wave height increase, by up to 0.02 m yr^{-1} (Bertin et al., 2013) in the Atlantic Coast of Europe, and high levels of storminess measures have also been observed in many parts of central, western and northern Europe (Donat et al., 2011). However, there is little consensus in the literature on the projections of extreme events occurrence, intensity, and frequency. An extensive review can be found in Seneviratne et al. (2012). Moreover, available studies demonstrate that extreme weather events can produce more intense detrimental physical impacts on beach availability in the short run than those from SLR, although the literature is more focused on the latter. A recent study of the 2015–2016 El Niño events (Barnard et al., 2017) revealed that the shoreline retreats experienced by the six regions of the US West Coast in the winter of 2015–2016 was 76% above the normal winter erosion rate. Similarly, the stormy winter of 2013–2014 along the Atlantic coast of Europe was found to have changed dramatically the equilibrium state of the beaches (beach gradient, coastal alignment, and nearshore bar position) (Masselink et al., 2016). The effects were found to vary depending on obliqueness of the waves and not only lead to beach erosion but also to beach rotation (Burvingt et al., 2016). The immediate economic impacts of events such as El Niño can be quite considerable, reaching US$11.5 billion globally (NOAA, 2016). On the demand side of socio-economic impacts, the few publications are consistent in finding a negative impact on tourist arrivals in the short term, and a negative impact on tourists' expenditures in the long run (Ghartey, 2013). It is crucial that future research aim at downscaling the models of frequency and intensity of extreme events to evaluate more precisely the impact on the coastline and the socio-economic impact.

In this stream of literature, most publications do not specify in which CC scenario the climate and socio-economic impacts (referred as Representative Concentration Pathways – RCP scenarios) are being forecasted; moreover, the economic impacts are not based on a homogenous measurement unit (e.g. cost of beach restoration per 1 metre) which makes the comparability and the extrapolation of values to other regions difficult. Further research is thus required to create a homogenous basis of knowledge aimed at enabling a more straightforward comparability of results, with useful implications for decision making at destinations.

3.1.3. Loss of attractiveness due to increased danger of forest fires in tourism areas

CC may also impact destinations through a change in the probability of wildfire occurrence. Wildfire outbreaks are particularly likely when humidity is extremely (unusually) low while temperatures are extremely high, resulting not only in physical damage to the forests, but also to severe increase in pollution and excess deaths (Shaposhnikov et al., 2014). A summary of papers analysing the loss of attractiveness due to increased risk of forest fires is presented in Table 4.

While in many areas the physical impacts of CC are likely to drive to higher probability of forest fires and substantial increase of fire-vulnerable areas (Abrha & Adhana, 2019), the analysis of publications investigating socio-economic impacts highlights negligible effect of wildfires on the attractiveness of the destination. A notable exception is a study by Otrachshenko and Nunes (2019), which reveals that burned areas have a negative impact on the number of tourist arrivals. The authors estimate that projected costs to the Portuguese economy due to the impact of burned areas in 2030 will reach € 17–24 million for domestic and € 18–38 million for inbound tourism, while in 2050, costs may increase at least fourfold.

Despite the fact that wildfires often result in large losses of forests and even human lives, this IC is among the least represented in the current literature, with much more emphasis given to recovery strategies (Lynch, 2004), than to tourists' behaviour. On the demand side, there is mixed evidence on the attitude and behavioural response of tourists towards fires (Englin et al., 2001). On the one hand, tourists do realize the importance of well-developed forest management programmes (Bonnieux et al., 2006a) and are willing to pay for policies reducing the severity of fire damage (Kountouris &

Table 4. Summary of impacts corresponding to *Loss of attractiveness due to increased danger of forest fires in tourism areas.*

Impact Studied	Reference	Results
Health and biodiversity (only physical impact)	Shaposhnikov et al. (2014)	Forest fires not only caused damage to forests, but also led to an increase in pollution and 11,000 excess deaths over only 6 weeks (Russia).
	Abrha and Adhana (2019)	The size of forest fire-vulnerable areas might be increased, due to climate change, to 12.85, 18.8, 17.1 and 46.26% in Mid-RCP4.5, Mid-RCP8.5, End-RCP4.5 and End-term-RCP8.5 respectively. Fire may occur in winter and spring seasons. (Desa'a, Ethiopia)
Tourists' valuation and behaviour	Bonnieux at al. (2006a)	WTP for fire protection is €39.5–47.2 per household per year for residents; and €5 per vehicle per visit for visitors (Corsica).
	Kountouris and Remoundou (2011)	WTP for reducing fires with size over 500 ha. is €57.88 -74.89. Mean yearly welfare cost of forest fires are: €317 (France); €1778 (Italy); € 3165 (Portugal); € 2,900 (Spain).
	Thapa et al. (2013)	About 33% of tourists are not at all discouraged by fire risk factor, while 42% would change their behaviour only if the risk is very high (Florida).
Economic impacts	Englin et al. (2001)	Impact of forest fires on recreation value: the mean value of a hiking trip is $109-$222 (National Forests).
	Cioccio and Michael (2007)	Fire-induced increase in insurance costs can be more considerable than direct impacts, especially for small businesses.
	Hystad and Keller (2008)	Businesses report of being affected in the short-run, but not in the long-run.
	Otrachshenko and Nunes (2019)	Burned areas have a negative impact on the number of tourist arrivals: estimated costs to the Portuguese economy due to the impact of burned areas in 2030 range between 17.03 and 24.18 million Euros for domestic tourist arrivals and between 18.26 and 38.08 million Euros for inbound ones. In 2050, those costs will increase at least fourfold (Portugal).

Remoundou, 2011). On the other hand, a considerable share of tourists is completely insensitive to fire risks and does not intend to change travel plans even when informed about wildfires present in the destination (Thapa et al., 2013). Finally, although the immediate effect of fires can be negative, long run alterations in tourists' behaviour are not expected (Hystad & Keller, 2008).

Regarding the supply side, a somehow similar picture appears; businesses report being affected in the short run, but not in the long run (Hystad & Keller, 2008). In some case, indirect impacts stemming from the increased probability of wildfires (e.g. higher insurance costs) can be more important than direct ones, especially for small businesses (Cioccio & Michael, 2007).

Although forest fires can affect tourism demand due to increases in health risks, deterioration of the destination image, and reductions in the value tourists attach to affected landscape and reduced biodiversity, research on this topic is overlooked. Moreover, research has paid very little attention to the moderating effect of Early Warning Systems, active in many destinations. We therefore suggest that these under-investigated topics should be studied more thoroughly.

3.1.4. Loss of attractiveness of land environments due to loss of species, increase of exotic invasive species or degradation of landscape

Concerning the impacts of CC on land environments biodiversity, a wide range of studies suggest that CC can induce species migration (Bender et al., 2019), but also lead to loss of habitats therefore increasing risk of extinction (Da Silva et al., 2019; Wan et al., 2019). As regards socio-economic impacts, this IC is one of the least investigated and, to the best of our knowledge, only two papers published in the last twenty years study the impact of changes in land environment on tourist satisfaction in coastal areas (Hakim et al., 2005; Seekamp et al., 2019), while no papers investigate the supply-side. However, there are a few contributions on the reverse impact: how tourism contributes to the invasive species diffusion (Anderson et al., 2015), to biodiversity loss (Steven & Castley, 2013) and, consequently, to the estimation of the WTP of tourists for adaptation measures for biodiversity preservation (Bonnieux et al., 2006b; Faccioli et al., 2014). A summary of papers analysing the loss of attractiveness of land environments due to loss of species, the increase of exotic invasive species, and the degradation of landscape is presented in Table 5.

The lack of research on land environment sums to the scattered evidence on the impact of forest fires recalled in the previous sub-section, and suggests that sea & sun tourists hosted by coastal destinations do face the sea: everything that happens behind, on the land or in the forests, seems to have little importance for them, and hence for research. However, it appears that this line of investigation on the value of natural capital (Wilson, 2010) is highly demanded by practitioners and public bodies. Somewhat similar to the fact that forest fires costs are typically evaluated ex-post by local or national authorities, the costs of invasive species and the value of biodiversity are studied by practitioners with results presented in the form of notes and reports (Bonnieux et al., 2006b; Williams et al., 2010).

3.2. Loss of tourist experience value in the destination due to changes in human being comfort

3.2.1. Loss of comfort due to thermal stress and heat waves

Abundant literature provides evidence of tourism being a highly weather-sensitive activity (Becken, 2010; Maddison, 2001; Scott et al., 2008). This relationship stems from the impact of temperature on human being comfort. Tourists acknowledge and perceive climatic comfort as more relevant than risks of SLR or changes in biodiversity (León et al., 2014). On the extensive margin, weather and climate directly affect tourism industry through tourists' destination choice (Gössling et al., 2006); on the intensive margin, they change activities and their timing (Cavallaro et al., 2017; Gómez-Martín et al., 2014), generating changes in tourists' flows and geographical concentration of activities within destinations. A summary of papers analysing the loss of comfort due to thermal stress and heat waves is presented in Table 6.

Table 5. Summary of impacts corresponding to *Loss of attractiveness of land environments due to loss of species, increase of exotic invasive species or degradation of landscape*.

Impact Studied	Reference	Results
Physical impact on land environments	Bender et al. (2019)	CC is expected to decrease functional diversity in the lowlands, increase it at lower mid-elevations and produce negligible changes at high elevations for frugivorous bird assemblages along a 3000 m elevational gradient in the tropical Andes.
	Da Silva et al. (2019)	Under current RCP scenarios, out of 2,354 microendemic species of seed plants in Brazil almost 70% (1,597) are projected to be under high extinction risk by the end of the century.
	Wan et al. (2019)	The California, northern and Mexican spotted owls are expected to have a 3-fold, 10-fold and 13-fold increase in area burned within its range by the 2080s respectively.
Tourists' valuation and behaviour	Hakim et al. (2005)	Invasive plant species led to disappearance of native plants, which were the main food source for *Bos javanicus* – the main attraction of the park. This resulted in decrease in their numbers and subsequent visitors' dissatisfaction (Alas Purwo National Park, Indonesia).
	Bonnieux et al. (2006b)	WTP for adaptation measures for biodiversity preservation is €30.8–38.6 per household per year for residents and €3.2 per vehicle per visit for visitors (Corsica).
	Faccioli et al. (2014)	Economic value changes in the number of bird species: marginal WTP/visitor/trip for the wetland is €1 for generalist migratory species and €1.31 for specialist species (Albufera Natural Park, Mallorca, Spain).
	Seekamp et al. (2019)	They reveal the thresholds of negative changes to coastal attributes that tourists are willing to tolerate, also examining tourists' willingness to substitute their future trips to the region.
Economic impacts	Williams et al. (2010)	Costs of the impacts of invasive non-native species for leisure and recreation: £165.6 million for Japanese knotweed; £25.5 m. for floating pennywort; £2.7 mill for signal crayfish (UK).
	Wilson (2010)	Total annual value of natural capital is $5.4 billion; forests ($5,913- $7,432) and wetlands ($4,017-$5,996) are the most valuable per hectare terms; the NPV is $43,678-$122,844.

The relationship between weather conditions, climate variables and tourists' comfort is complex and the focus of numerous studies. To measure the suitability of climate for the tourism sector the literature resorts to different variations of the Tourism Climatic Index (TCI), originally proposed by Mieczkowski (1985), which includes several weather dimensions (e.g. mean temperature, humidity, precipitation, etc) and has an easy interpretation. Mieczkowski's original index has been modified and adapted, leading to alternative versions (de Freitas, 2006), to modified indices for specific types of tourism (Moreno & Amelung, 2009), or to area-specific versions, with a special focus on Europe and the Mediterranean region (Amelung & Viner, 2006; Moreno & Amelung, 2009; Morgan et al., 2000; Perch-Nielsen et al., 2010), or at global scale (Amelung et al., 2007). This metrics is then used to obtain projections of seasonality changes induced by CC in various regions. Since TCI is widely used and allows incorporating climatic variables projections, many studies can produce socio-economic projections directly derived from CC scenarios, therefore physical and socio-economic impacts are well-connected.[3]

For the Mediterranean region there is evidence that temperatures will become too hot in the summer season, but destinations would be more pleasant in the shoulder seasons. In the case of the Balearic Islands, these changes are positive from the resource management and biodiversity point of view, while social and economic effects are likely to be detrimental (Amelung et al., 2007; Amelung & Viner, 2006).

Table 6. Summary of impacts corresponding to *Loss of comfort due to thermal stress and heat waves.*

Impact Studied	Reference	Results
Tourists' comfort and thermal comfort indices	Amelung et al. (2007); Amelung and Viner (2006)	Under IPCC-2100 climate change scenarios, Mediterranean will become too hot in summer, but a more pleasant destination in shoulder season.
	Morgan et al. (2000); Scott et al. (2008); de Freitas (2006)	The preferred temperature varies by type of tourism: 27°C (beach), 22°C (urban), 20°C (mountain). Indices that calculate only thermal conditions (e.g. physiological equivalent temperature) can mislead the assessment of the quality of climate for tourism, because they do not take into account the relationship with the tourist's satisfaction or decision-making.
	Becken (2010)	Due to the large number of impact channels, the effect of climate change on tourist comfort and arrivals is extremely heterogeneous across the globe.
	Moreno and Amelung (2009); Burvingt et al. (2016); Rutty and Scott (2015)	New body of literature on climate indices: Holiday Climate Index (HCI), where the variable rating scales and the component weighting system use values from previous empirical studies on tourists stated climatic preferences
Tourists' valuation and behaviour	Maddison (2001)	Under UKMO's climate change scenario for 2030, the number of British tourists will increase by 2.9% in Greece and by 8.1% in Spain.
	Richardson and Loomis (2003)	OLS regression analysis to model the behaviour of visitors as a function of climate scenario variables and demographic variables. 7% of visitors stated they would visit less often because of weather discomfort (Colorado State, USA).
	Gössling et al. (2006)	Weather and climate directly affect tourism industry through tourists' destination choice (extensive margin).
	Gómez-Martín et al. (2014)	Due to the 2003 heat wave, many tourists switched to indoor activities; 25% reported substantial increase in water consumption. Younger people are less susceptible to extreme weather conditions than the elderly (Spain).
	León et al. (2014)	WTP to avoid the risk of health effects is €547.17, which is higher than WTP for mitigation of SLR and biodiversity loss (Canary Islands).
	Cavallaro et al. (2017)	Climate changes the type of available activities and their timing (intensive margin), generating changes in tourists flows within destinations.
Economic impacts	Toloo et al. (2015)	Increased temperatures impact Emergency Rescue admissions: excess number of visits in 2030 are estimated to be 98–336 for younger groups and 42–127 for older, with associated costs of AU $51,000–184,000 and AU$27,000–84,000 (Brisbane, Australia)

While high temperatures are generally associated with higher risks of dying from cardiovascular, respiratory, and cerebrovascular diseases, these risks are substantially more pronounced for young children and people older than 65 (Basu, 2009), therefore, younger tourists are less sensitive to extreme weather conditions than the elderly (Gómez-Martín et al., 2014). High temperatures also have an indirect impact on the healthcare system, due to the increased numbers of hospital admissions (Toloo et al., 2015). Additionally, tourists' comfort may be indirectly affected through a decrease of water availability (itself also a consequence of extra-demand of water generated by tourism, Gómez-Martín et al., 2014).

Overall, the economic impact of thermal stress has received scant attention in the literature, despite its relevance for tourists and the fact that using TCI or similar metrics substantially facilitates analysis for CC-induced socio-economic impacts. Hence, more research is needed in this sub-field. Another important issue is the fact that climatic models for island destinations and coastal areas are highly uncertain; in this regard, downscaled evaluations regarding physical impacts and tourists' perceptions, in a comparative perspective, would be really appreciated.

3.2.2. Increase of health issues due to emergent infectious diseases

Apart from the direct effect due to thermal stress, CC is expected to have pronounced indirect effects via disease spreading. Existing literature on the physical impacts often suggests an increase in the spread of various diseases caused primarily by higher temperatures (Yang et al, 2008), though the impacts may differ depending on the exact region or vector under study (Ryan et al., 2019). We note that many analyses of physical impacts provide qualitative rather than quantitative conclusions, which calls for more quantitative research in this area.

Considering globalization and increased population mobility, the geography of certain diseases is changing rapidly, urging to be seriously considered in the process of diagnosing. Tourists are a particularly vulnerable population subgroup, especially when they choose a destination with environmental features which are drastically different from those of their country of origin. The health and medical literature, however, generally does not focus on tourists, and more often considers increased risk for various demographic groups of the indigenous population. One of the exceptions is the analysis of Lau et al. (2010a; 2010b) who suggest that higher temperatures, extreme weather events and flooding will result in increased incidence and magnitude of leptospirosis, putting at higher risk adventure-seeking tourists because the disease is often under-diagnosed in their home countries. Therefore, it should be noted that different types of tourism exhibit different exposure to health risks: e.g. cruise tourism is one of the most vulnerable (Liu and Pennington-Gray,2017). A summary of papers analysing the increase of health issues due to infectious diseases is presented in Table 7.

Few studies focus on how tourism demand is affected by vector-borne infectious disease outbreaks. From an economic perspective, disease spreading can have significant economic impacts on the tourism destination, mainly decreasing tourism arrivals. Developing countries are likely to be the most vulnerable since they are often highly dependent on the tourism industry and have lower levels of health care services and hygienic conditions. Existing evidence refers mostly to assessing losses from past epidemics (Panzer and Saavedra, 2016), while little research has investigated hypothetical or projected impacts. A notable exception is the analysis of potential losses for the tourism industry in a hypothetical scenario of chikungunya and dengue outbreak in Gujarat (India), Malaysia, and Thailand (Mavalankar et al., 2009). The losses of tourism revenues are estimated to be US$ 8 million for Gujarat, US$ 65 million for Malaysia, and US$ 363 million for Thailand, whereas the direct annual cost of chikungunya and dengue for these economies are US$ 90 million, US$ 133 million, and US$ 127 million respectively, thus revealing that highly tourism-dependent Thailand would incur extremely high losses.

The 2020 outbreak of COVID-19 shows that the impact of a serious disease in a tourism destination is highly disruptive, with the whole sector quickly heading to a complete stop. Such serious diseases are likely to modify tourists' behaviour also in the medium-long term. A few research

Table 7. Summary of impacts corresponding to *Increase in health issues due to emergent diseases.*

Impact Studied	Reference	Results
Physical impact	Ryan et al. (2019)	The authors project poleward shifts in Aedes-borne virus distributions with more severe CC scenarios producing larger population exposures to transmission by Ae. aegypti, but not by Ae. albopictus (for Ae.albopictus the increase in transmission occurs at intermediate CC scenarios). While CC-induced risk of transmission from both mosquitoes is expected to increase for most of Europe, decrease in their habitat suitability is projected for southeast Asia and west Africa.
	Yang et al. (2008)	Based on temperatures projections for China, the authors predict the expansion of schistosomiasis transmission into currently non-endemic areas in the north, with an additional risk area of 783,883 km2 by 2050, translating to 8.1% of the surface area of China.
Impact on tourists' health	Lau et al. (2010a, 2010b)	Increased temperatures, extreme weather events and particularly flooding will result in increased incidence and magnitude of the outbreaks of leptospirosis, with tourist being particularly at risk due to under diagnosis.
Economic impacts	Mavalankar et al. (2009)	Estimate losses of tourism revenues are US$ 8 million for Gujarat, US$ 65 million for Malaysia, and US$ 363 million for Thailand in case of potential chikungunya and dengue epidemic.
	Panzer and Saavedra (2016)	Zika Virus epidemic in 2016 for the Latin American and the Caribbean region is valued at US$3.5 billion or 0.06% of GDP. For some of the tourism-dependent small islands in Caribbean region, the cost rises to 1.6% of GDP.

questions, that are not directly linked to CC but that will reshape tourism research in the near future are: would tourists decide (or be forced) to travel closer to their home, leading to a new tourism geography? Would they avoid massification, with a consequence for sea & sun models to be in very high risk of obsolescence? How long will it take to international tourism arrivals to restore their previous figures? On the other hand, global travel restrictions have led to a rapid recovery of certain ecosystems, which can have a drastic impact on the behavioural response of the more environmentally responsible tourists. Such a vision requires a centred tourism framework that redefines and reorients research after COVID-19 pandemic. This is essential for tourism to be made accountable to social and ecological limits of the planet. The literature reported in Table 7 can be considered a useful starting point also for this stream of research.

3.3. Loss of tourist experience value in the destination due to the change in the quality of infrastructures and facilities

3.3.1. Increase of damages to infrastructures and facilities (accommodation, promenades, water treatment system, etc)

Infrastructure and facilities play an important role in providing tourism services. Not only accommodation, but a wide range of amenities contribute to the attractiveness of a destination and CC can have both direct and indirect effects on transportation (Della Corte et al., 2015), restaurant services (Szende et al., 2018), recreation facilities and amusement parks (Zopiatis et al., 2017), etc. A summary of papers analysing the impacts stemming from CC to infrastructures and facilities is presented in Table 8.[4]

The quantity and intensity of precipitation affects transport demand through its influence on the choice of transportation mode, trip postponement or cancellation (Koetse & Rietveld, 2007; Koetse & Rietveld, 2009). For the aviation sector, the crucial factors are wind speed and direction; however, the potential impacts of CC are viewed as ambiguous, since the impacts may affect transport infrastructure in different directions (Koetse & Rietveld, 2009). As regards road and railway infrastructure for the EU area, degradation rates are not projected to increase substantially, as more frequent extreme weather events may induce considerable additional costs in summer season while reducing them in winters (Nemry & Demirel, 2012).

Table 8. Summary of impacts corresponding to *Increase of damages to infrastructures and facilities (accommodation, promenades, water treatment system, etc.)*.

Impact Studied	Reference	Results
Tourists' valuation and behaviour	Koetse and Rietveld (2007); Koetse and Rietveld (2009)	Quantity and intensity of precipitation have an effect on transport demand, affecting the choice of transportation mode, trip postponement or cancellation.
	Pearlman and Melnik (2008)	Negative impact of Hurricane Katrina on the New Orleans destination image through damage to infrastructures.
Economic impacts	Nemry and Demirel (2012)	At EU27 aggregated level normal degradation rates of road transport infrastructures will only slightly increase in the future (according to A1B scenarios for 2040–2100). However, more frequent extreme weather events may induce additional cost of 50–192 million €/yr. In contrast, softer winter conditions are projected to reduce the costs by 170–508 million €/yr.
	Moore et al. (2010)	For different scenarios of land loss, inundation and flooding due to SLR and hurricanes until 2100, the projected losses in tourism revenues due to infrastructural damage reach $267–$1477 m. (Barbados).
	Basker and Miranda (2014)	Hurricane Katrina resulted in severe short-term damage for all businesses, especially for small and less productive ones due to increased competition.

Restaurants and other facilities are also directly influenced by weather events and CC. Extreme events are the most damaging and may have severe consequences, especially for small and marginal businesses with reduced access to financial markets. These effects can be even more pronounced in the long run, if the area is characterized by a high degree of competition (Basker & Miranda, 2014), which is often the case for coastal areas. It is important to note that infrastructural damages resulting from extreme events are often much higher than those from gradual CC processes (Moore et al., 2010).

On the demand side, it has been proven that damages to different infrastructures have a negative impact on the destination image, especially for tourists who have never visited the destination before (Pearlman & Melnik, 2008). In this regard, being the destination image an antecedent of tourist satisfaction, repetition and repurchase intentions, studies aiming to assess these relationships are strongly needed.

3.3.2. Decrease of available domestic water for the tourism industry

Climate Change can also indirectly impact the quality of the services provided by the facilities, for instance, through the availability of water. This aspect receives plenty of attention from the literature, especially when it comes to countries which already suffer from water scarcity. As regards physical impacts, it is expected that CC will cause wet tropical regions to get wetter and subtropical dry regions to become drier, reducing soil moisture and runoff (Seager et al., 2013), while for northern regions the water stress is projected to reduce (Koutroulis et al., 2019). Water availability is one of the most intrinsically complex factors, as it is determined by a huge number of variables apart from most obvious temperatures and precipitation: plants vegetation response (Mankin et al., 2019), population growth, ageing and water supply infrastructure (Kristvik et al., 2019).

Moving to socio-economic impacts, while tourism-related direct water consumption was globally estimated to be less than 1% of total consumption, and is expected to remain negligible even when taking tourism growth projections into account (Gössling et al., 2012), for heavily tourism-dependent countries the sector is one of the major water consumers. In Barbados, for instance, the average per capita consumption associated with tourism is three times higher than the one of domestic consumers, and water demand by the tourism sector is projected to rise from the current 12% to 18% of total local consumption in 2050 (Cashman et al., 2012). Given that most of the CC projections predict a decrease of precipitation levels for Barbados (Cashman et al., 2010), freshwater scarcity is expected to be a serious issue affecting the whole economy, including tourism, resulting in increased operating costs, and consequently, increased prices (Cashman et al., 2012). This may lead to significant changes in the market, giving a comparative advantage to large hotels and resorts, since they are usually more efficient in water consumption because of economies of scale (Gabarda-Mallorquí et al., 2017).

Furthermore, for countries where tourism is a major sector, the needs of tourists might be prioritized over the needs of the local population, generating potential for local conflicts, instability, and marginalization (LaVanchy, 2017). It is important to note that developing countries are not the only focus of the literature: in the context of the Mediterranean region, for instance, it addresses concerns about how decreasing rainfall impacts water supply availability (Philandras et al., 2011) and related costs (Martínez-Ibarra, 2015). The literature also tackles important methodological aspects of measuring water footprint, such as comparing direct with indirect water consumption: although the latter is often overlooked, it may account for a much larger share of water consumption from tourists than the direct one (Hadjikakou et al., 2013). A summary of papers analysing the IC stemming from the decrease of available water for tourism is presented in Table 9.

Summing up, being water an essential resource, its shortage may highly damage the destination competitiveness. Yet, not all tourism types depend on water in the same way and intensity. Coastal tourism is highly demanding of water for sanitation, food cooking, and recreational activities. Water shortage at these destinations may affect tourists in a more pronounced way, through lesser water-based recreation provision and water supply shutdowns in hotels. Thus, economic values for water restrictions cannot be easily used for assessing the potential impacts at those destinations for which there is no empirical evidence in this respect, which justifies the need of more case studies. Finally, the literature of the last twenty years does neither refer to water supply shutdowns affecting tourists' well-being at the destination nor assesses changes in the probability of choosing a destination potentially affected by this issue. These are avenues for future research.

Table 9. Summary of impacts corresponding to *Decrease of available domestic water for the tourism industry.*

Impact Studied	Reference	Results
Physical impacts	Koutroulis et al. (2019)	Under 'no adaptation' scenario, at 2 °C global warming about 2.7 billion people globally will face higher freshwater stress. At the 4 °C global warming this number increases by 200 million more people.
	Kristvik et al. (2019)	Using water availability index (WAI) which incorporates impacts of CC, population growth, and ageing infrastructure, as well as the effects of implementing counteractive measures, the study projects decreased water availability for the city of Bergen, Norway, with stronger seasonal variations and a higher uncertainty in water availability.
	Mankin et al. (2019)	CC-induced plant responses directly decrease future runoff across vast territories of North America, Europe and Asia, even in regions with increasing or unchanging precipitation.
	Seager et al. (2013)	In the near future (2021–2040) surface-water availability across the southwest of US is expected to decline, translating into reduced soil moisture and runoff in California and Nevada, the Colorado River headwaters and Texas.
Tourists' valuation and behaviour	Gössling et al. (2012)	Direct tourism-related water use is less than 1% at the global scale and will remain small even if the sector continues to grow at a rate of 4% per year.
	Martínez-Ibarra (2015)	The draught in Benidorm (Spain) reduced arrivals from Germany, France and Scandinavian countries.
	Hadjikakou et al. (2013)	Among tourists of Cyprus, Turkey, Greece and Syria, diet footprint accounts for 75–91% of the total water footprint.
Economic impacts	Cashman et al. (2010, 2012)	Increased operating costs and prices for tourism due to climate change induced water scarcity (Barbados).
	Martínez-Ibarra (2015)	The draught in Benidorm (Spain) substantially increased local government costs, requiring potable water supplies shipped from other sides of the world.
	Gabarda-Mallorquí et al. (2017)	Large hotels benefit in terms of economies of scale, being more water efficient. Hotels that belong to a chain are less efficient that individual hotels.
	LaVanchy (2017)	In Nicaragua, increased groundwater consumption is attributed to conflict and political instability.

Table 10. Summary of impacts corresponding to *Loss of attractiveness due to loss of cultural heritage*.

Impact Studied	Reference	Results
Tourists' valuation and behaviour	Becker and Katz (2006)	WTP to protect and preserve the Dead Sea basin is $59,148,000, generating a consumer surplus of $193 m. according to the travel cost method. The value of avoided damages and defensive expenditures is $16.3 m.
	Alberini and Longo (2009)	Total benefits of a nationwide conservation programme of tangible cultural heritage in Armenia are estimated to be US $6.2–6.8 m.
	Giannakopoulou et al. (2011)	WTP to protect and preserve the traditional character is €30.4–45.6, and the annual aggregate value is €0.8–1.3 m.
	Báez-Montenegro et al. (2016)	To protect and preserve the heritage of Valdivia (Chile) the mean WTP is 11,443 Chilean pesos.
Economic impacts	Grøntoft (2017)	The projected impact of climate change and air pollution on conservation-restoration costs of limestone façades is 7, 12 and 19% of the weathering cost at present (2013–2015), for 2020 and for 2050 targets, respectively.

3.3.3. Loss of attractiveness due to loss of cultural heritage

Lastly, the impact of CC on the cultural heritage may have important implications for tourism, especially in those segments for which cultural attributes (monuments, architecture, etc.) are the very purpose of the trip. As regards physical impacts (note that in this case they can be immediately translated into supply-side economic impacts), the few existing studies on this topic are focused on estimating the costs of conservation-restoration of different types of cultural heritage after damages due to CC (Grøntoft, 2017; Hall et al., 2016). A summary of the existing studies analysing the loss of attractiveness due to loss of cultural heritage is presented in Table 10.

When on holiday, tourists allocate a budget for different activities, including visiting cultural sites. Accordingly, a WTP for conservation of cultural heritage can be estimated (Becker & Katz, 2006), which is found to be more determined by tourists' income than by considerations on the cultural attributes of the specific cultural asset. Additionally, the WTP is also mediated by the image of the destination and the travel motivation: tourists would pay more for cultural assets of highly regarded cultural destinations and when culture is the main motivation of their trip. Researches usually focus on very specific sites: e.g. Báez-Montenegro et al. (2016) analyze the case of Valdivia (Chile) and Giannakopoulou et al. (2011) estimate the monetary value of vernacular architecture of a small town in Greece – Metsovo. A notable exception with a broader coverage is the study of Alberini and Longo (2009), who apply contingent valuation to investigate the cost-efficiency of a hypothetical conservation programme for all cultural monuments in Armenia. Their analysis also incorporates uncertainty, which is an extremely relevant dimension associated to CC; the study reveals that uncertainty about what would happen to monuments in the absence of the programme results in decreased willingness to pay. However, the study was conducted using data from surveying local population rather than tourists. Accordingly, novel research can focus on the value that tourists give to appropriate maintenance plans of cultural attractions at the destination, followed by a comparative valuation among tourist types, destinations, and compared to the local population.

4. Conclusions and discussion

Climate change generates important effects on the tourism industry, since both supply and demand of tourism services depend upon the quality and the management of a set of environmental attributes which are under threat of modification by CC. This paper provides a literature review of recent findings, applying the Impact Chains methodological framework to interpret how CC physically and economically impacts coastal and maritime tourism. An expert assisted process identified three generic risks and nine specific IC, on which the literature is classified and examined.

4.1. Summary and discussion of main findings

The meta-evaluation of the literature casts lights and shadows. By the side of lights, there is abundant evidence on the effects of CC on the quantity of tourism flows, and the review allows to gather some information for all IC investigated. By the side of shadows, relatively few studies pin down the whole channel of transmission: in fact, papers either focus on the environmental (intermediate) impacts of CC, or on the effects of these intermediate impacts on the tourism industry, with only a few papers focusing on the full chain of interconnections (physical and economic impacts). Studies of the physical impacts of CC on tourism are more numerous, although the degree of robustness of their findings varies across IC: there is more confidence in the projection of impacts of sea level rise, and less confidence in the projection of impacts stemming from extreme events (e.g. storms) occurrence and intensity.

Secondly, the economic impact of CC is mainly studied from the demand side, looking at changes in the number of tourists or in their expenditure, while only a few contributions investigate the supply side. A relevant exception is related to the impact of sea level rise and of increased intensity and frequency of storms on infrastructures and facilities. Unfortunately, literature referring to the relationship between climate-induced impacts and the effect on the destination image is almost inexistent (de Almeida & Machado, 2019; Pearlman & Melnik, 2008). This relationship is important, as changes in the destination image are good predictors of destination choice, and in some cases, of tourists' satisfaction and expenditure decisions while at destination.

Thirdly, some IC are overlooked by the literature, being the scientific production very fragmented and unbalanced: for instance, while the risk of loss of tourism attractiveness due to the reduction of beach surface is examined by twenty publications, just three papers provide some information on the impact of infectious diseases in tourism destinations. At the time of COVID-19 outbreak, it is obvious that the spread of diseases is one of the main drivers of tourism flows, and research is much needed in this important topic. Moreover, very scant attention is given to the impact of wildfires and of changes in land environment, which mirrors the little interest that sea & sun tourists seem to show on what happens far from the beach, behind their backs. Finally, the impact of cultural heritage degradation on the destination image is neglected, while academic research focuses instead on the reverse link (that is, how tourism impacts land environments and cultural heritage). It is hence in these subfields of research that there is room for much needed future contribution.

4.2. Policy implications

Is it possible to use this evidence to build a bridge between academic research and practical climate risk assessment policies? In this respect, a relevant issue is whether findings reported in the literature can constitute a common groundwork for raising general conclusions about the potential impacts of climate change at coastal destinations. For instance, as regards the impacts due to loss of attractiveness of marine environments (species or landscapes), loss of comfort due to beach reduction, and loss of comfort due to thermal stress and heat waves there is sufficient empirical evidence that could lead to a common assessment from a policy perspective.

Unfortunately, the range of values for the economic impacts provided by the literature is too large to lead to such common ground. For example, Parsons and Thur (2008) find that the decrease in per-capita tourists' spending due to biodiversity loss in Thailand would range between $45 and $190 while Raybould et al. (2013) estimate that total tourism expenditure in Australia would drop between $20 and $56 million because of beach reduction. On a similar note, Bayraktarov et al. (2016) estimate that rehabilitation projects of marine environments would cost between $80,000 and twenty times this value ($1.6 million) per marine hectare in the five areas investigated. The range of these case-study empirical estimates is too wide, and generalization of results would be difficult. Moreover, a general assessment of coastal destinations is strongly conditioned by the extraordinary heterogeneity of destinations and of estimation procedures, as CC scenarios and measurement units are often not homogenous across studies.

It is difficult to generalize conclusions also as regards the impact of CC on tourists' behaviour. Studies differ too much in the selected variables (willingness/unwillingness to revisit, choice of alternative destinations, loss in the number of visitors, etc.) or in the criteria followed to delimitate the tourism destination (ranging from local resorts to countries, even to continents) to reach common conclusions in different contexts. Thus, assessing the potential impacts based on the empirical evidence is as much a desirable as a complex issue, because the available studies are specific to each destination.

The non-linearity of the processes at stake also plays an important role. A mismatch is evident here: on the one hand, climate has a non-linear dynamics, with events and conditions triggered by the passing of certain thresholds and that might hit similar or neighbour territories in completely different ways. Similarly, the reaction of tourism is sometimes very complex, as individual thermal stress, just to give an example, does not increase linearly with temperature, but appears (and strongly impacts behaviours) when a threshold of perceived temperature is reached. On the other hand, the great majority of socio-economic impacts in the literature is estimated through linear models and approaches, hence being partially unfit to take on the challenge. The use of non-linear methodologies to estimate the socio-economic impacts of CC is hence one of the most important avenues of research for CC induced impacts on tourism.

Gathering and examination of empirical evidence has another important policy implication. Through the consistent assessment of climate-related impacts and the joint identification of the associated economic and social costs, policy makers avail of a dashboard of indicators that, when fed with local data, would provide useful policy tools for destination management. This way, mitigation and adaptation efforts may be fine-tuned to minimize social costs associated with CC and with the transition to a decarbonized and more secure society. In this respect, some papers are valuable because they estimate the cost of adaptation policies aimed at reducing tourism vulnerability to CC and this information is useful to estimate the economic value of impacts based on avoided costs-type methodologies.

This paper is not free of limitations, which also constitute the main avenue for future systematic reviews. One, the present work only focuses on coastal and maritime tourism; the application of the IC conceptual framework based on the identification of specific IC to other types of tourism (mainly mountain, cultural and business tourism) and the subsequent critical review of the relevant literature is hence of paramount importance. Two, someone might be interested to work on a quantitative meta-analysis, although the diversity of methodologies and approaches used in the literature, and the wide range of available estimates cast a serious doubt on the feasibility of such analysis.

Notes

1. The Intergovernmental Panel on Climate Change is the United Nations body for assessing the science related to climate change and for providing policymakers with regular assessments on CC, its implications and potential future risks, as well as to put forward adaptation and mitigation options.
2. A whole strand of literature investigates the impact of climate change on mountain destinations, with a specific focus on winter tourism. We refer to Steiger et al. (2019) for a comprehensive review on the topic.
3. For this reason, we have focused only on the socio-economic impacts in this subsection.
4. Since the impact on hotel industry was largely covered in subsection 3.1.2, here attention is on infrastructure other than hotels.

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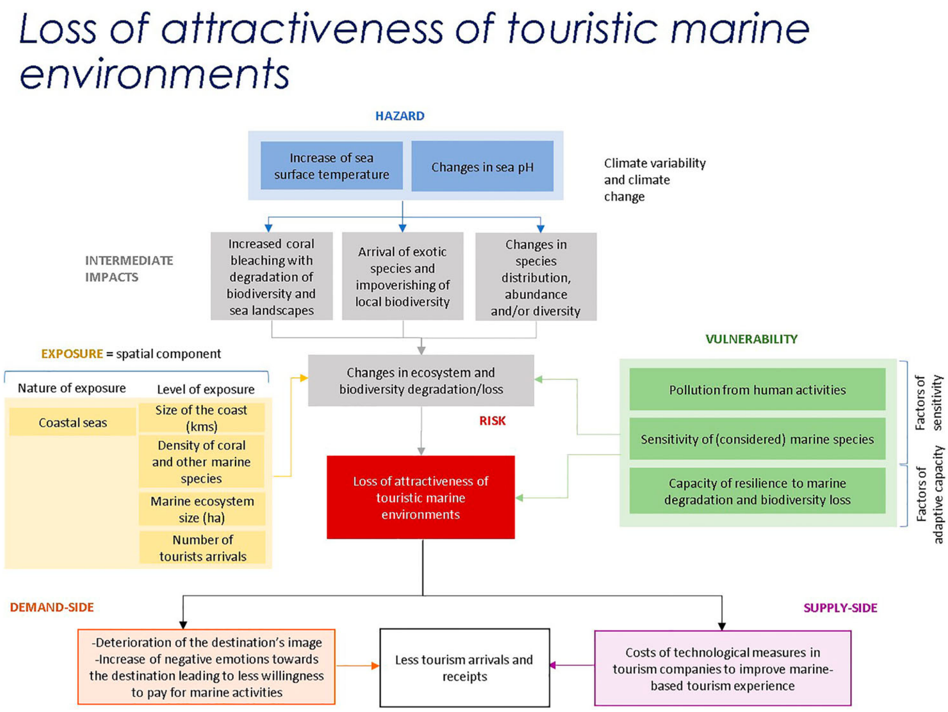
Appendix



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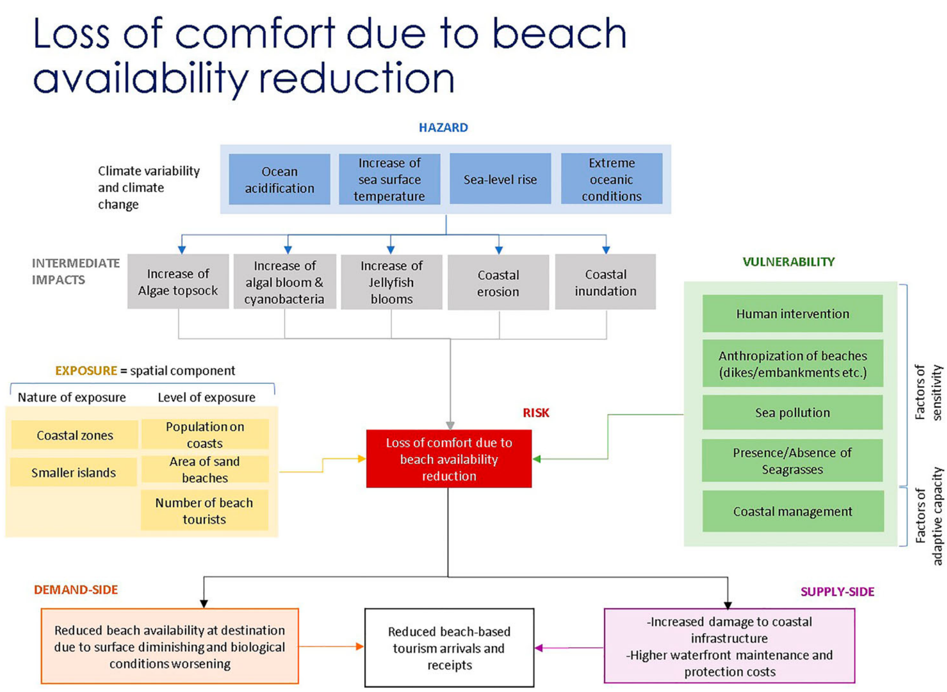

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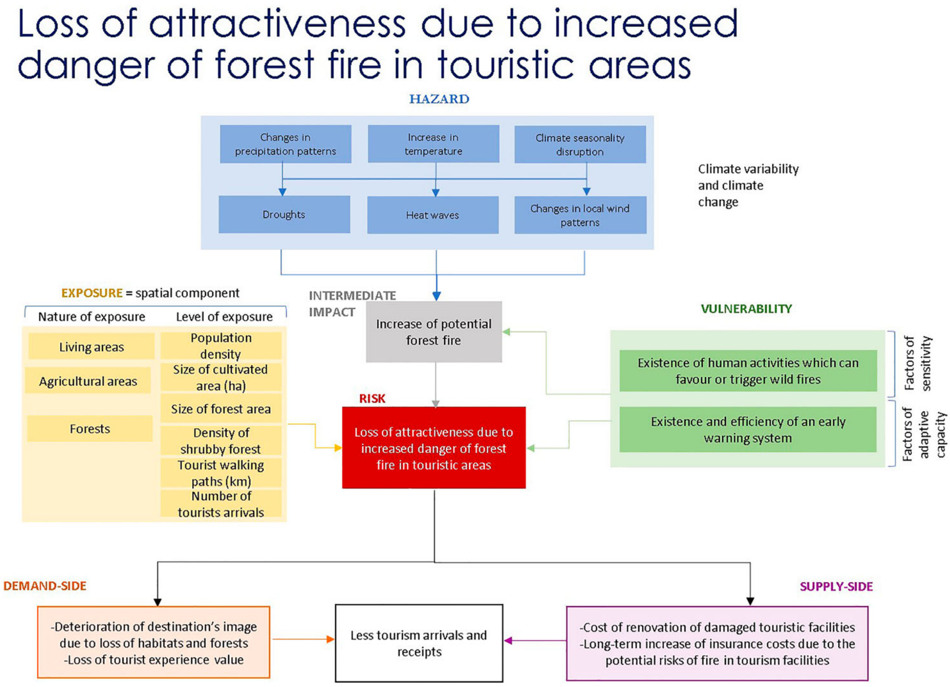

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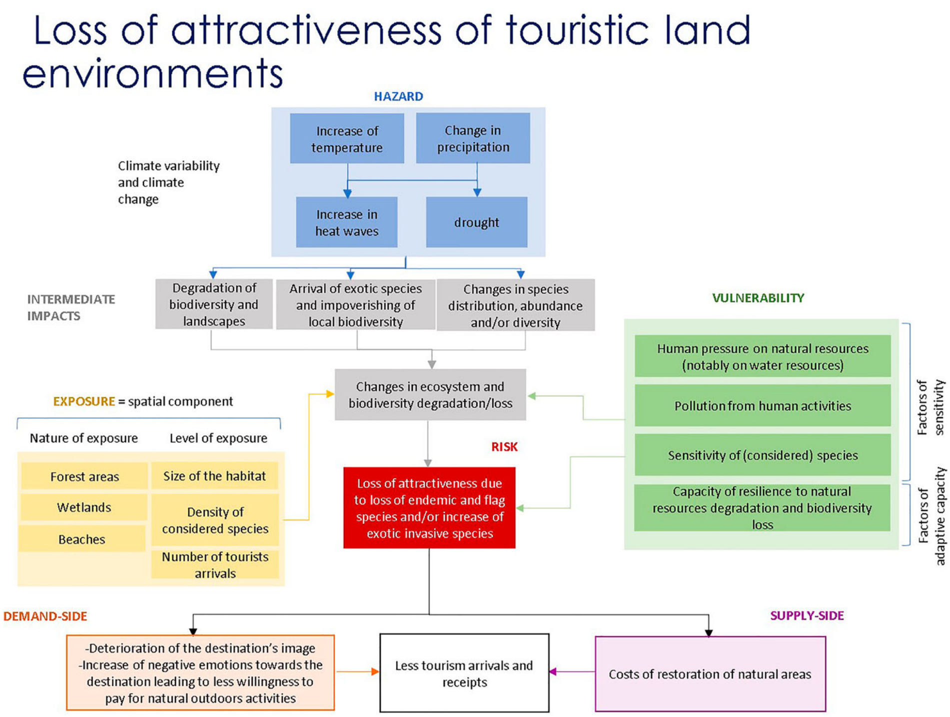

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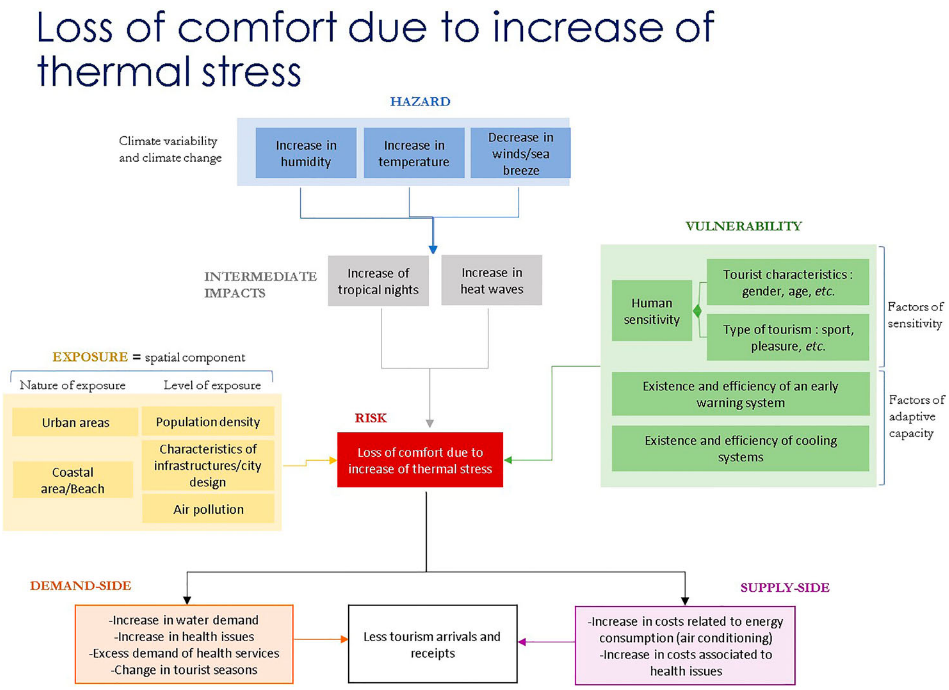

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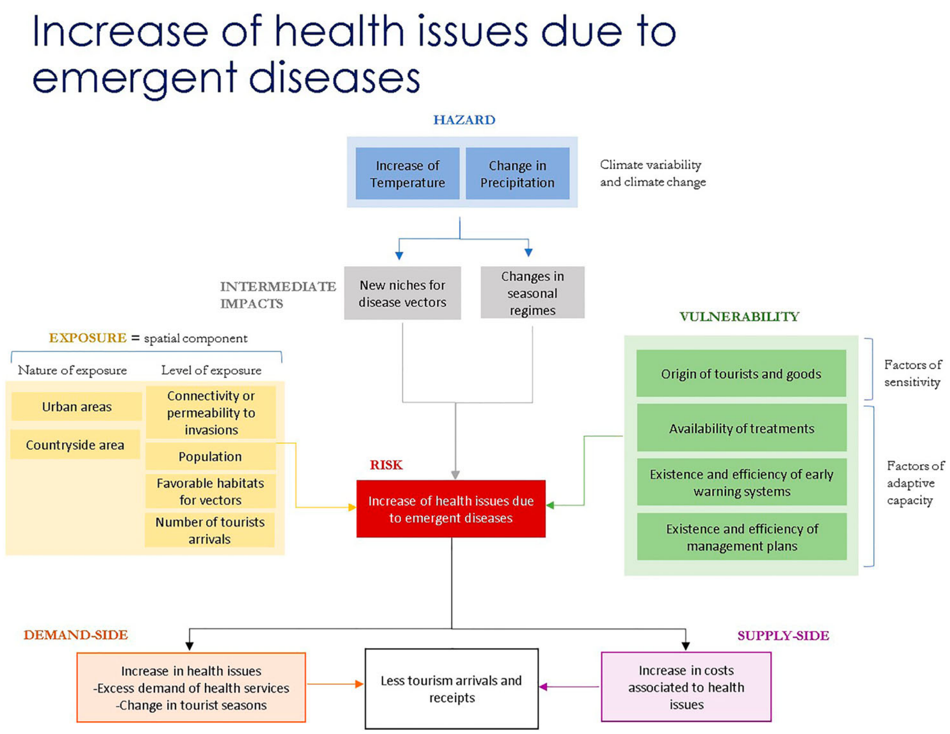

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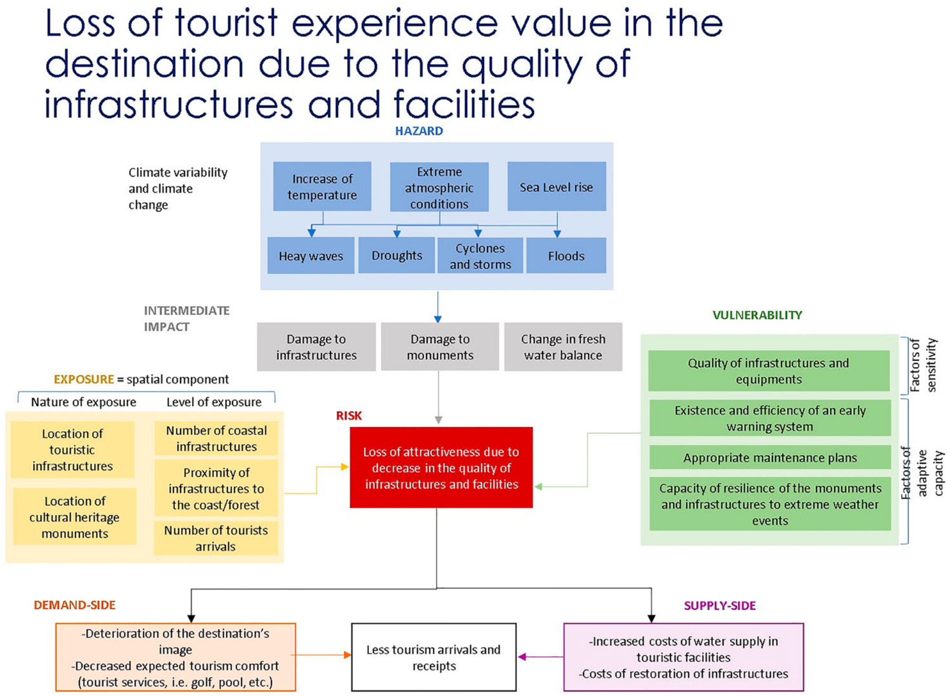

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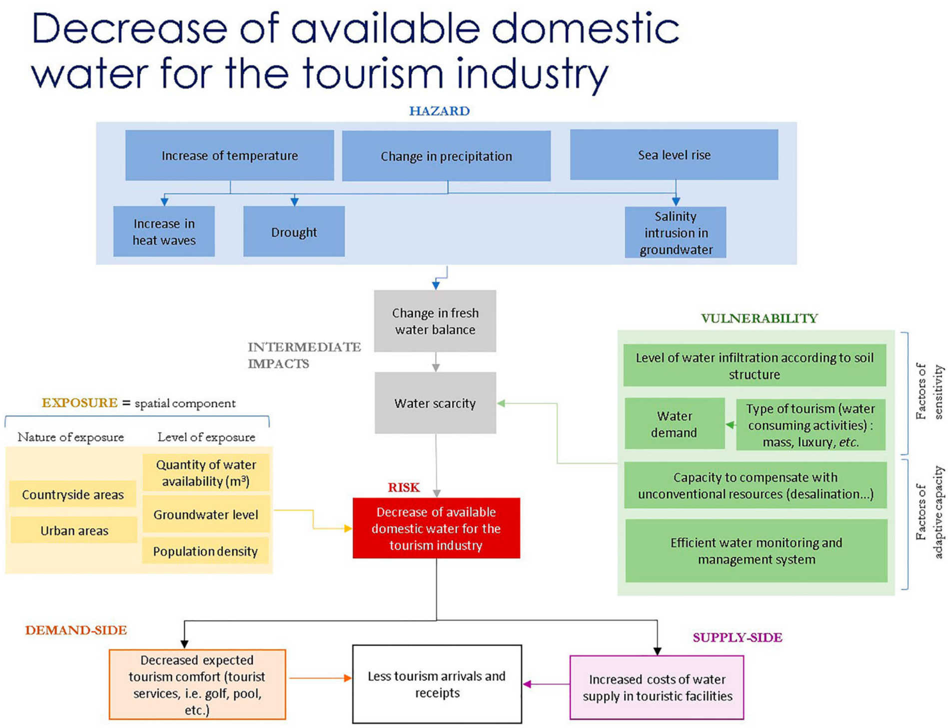

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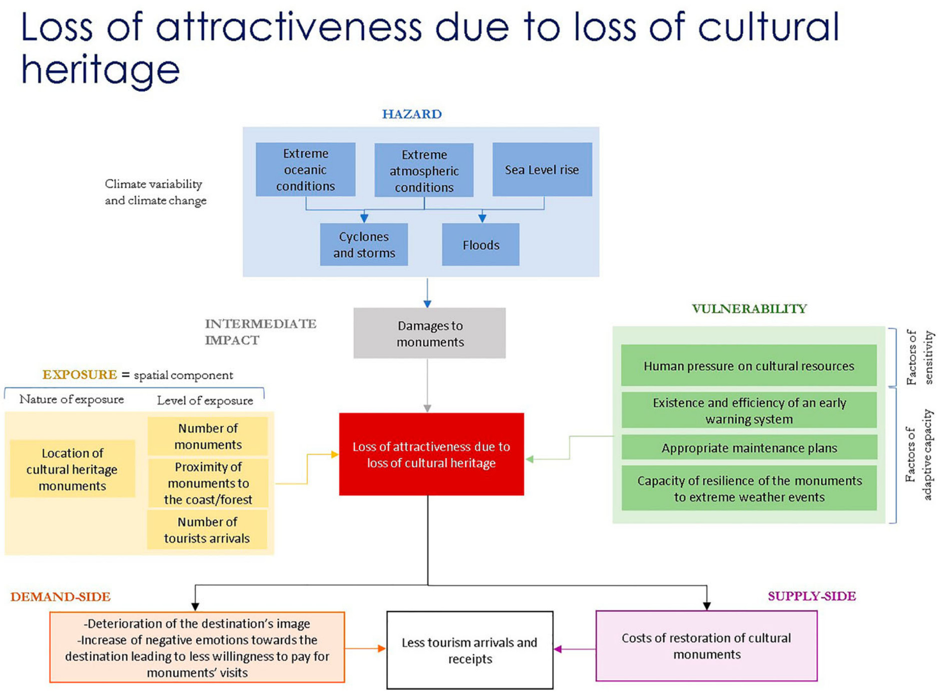
Loss of attractiveness due to loss of cultural heritage
HAZARD
Climate variability and climate change
Extreme oceanic conditions
Extreme atmospheric conditions
Sea Level rise
Cyclones and storms
Floods
INTERMEDIATE IMPACT
Damages to monuments
VULNERABILITY
Human pressure on cultural resources
Existence and efficiency of an early warning system
Appropriate maintenance plans
Capacity of resilience of the monuments to extreme weather events
Factors of sensitivity
Factors of adaptive capacity
EXPOSURE = spatial component
Nature of exposure
Level of exposure
Location of cultural heritage monuments
Number of monuments
Proximity of monuments to the coast/forest
Number of tourists arrivals
Loss of attractiveness due to loss of cultural heritage
DEMAND-SIDE
-Deterioration of the destination's image
-Increase of negative emotions towards the destination leading to less willingness to pay for monuments' visits
Less tourism arrivals and receipts
SUPPLY-SIDE
Costs of restoration of cultural monuments

Figure A9.