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Climate change: Vulnerability and resilience of tourism and the entire economy

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ABSTRACT

Fluctuating and extreme weather patterns are acute indicators of climate change and these patterns modify tourist activities. The tourism industry is thus considered highly vulnerable to climate change. However, the effects of climate change on tourism have not yet been extensively quantified. Furthermore, the extent to which tourism is vulnerable or resilient to climate change has not been compared to other sectors of the economy. This study examines the extent to which vulnerability and resilience to climate change affect tourism and the overall economy. The results indicate the effects of vulnerability are much greater than those of resilience. The tourism industry is more vulnerable, yet more resilient, to climate change compared to the overall economy. The strength of these effects varies across countries with different income levels: countries with the lowest income levels are more vulnerable and less resilient, and those with the highest income are the least vulnerable and most resilient.

1. Introduction

Climate change is anticipated to have adverse impacts on the tourism industry because climate is one of the key resources for tourism that shapes and drives its success (Hall, Amelung, Cohen, Eijgelaar, Gössling, Higham, et al., 2015). In an example reported by the United Nations Intergovernmental Panel on Climate Change (IPCC), "the tourism industry is likely to experience a reduction in ski season, loss of some ski areas, [and] shifts in the location of tourist destinations because of climate change" (2007, 790). The patterns of tourist flows, both domestic and international, are also expected to change in parallel with large-scale changes due to climate change (Bujosa, Riera, & Torres, 2015; Hamilton, Maddison, & Tol, 2005).

Despite the strong scientific evidence emerging from independent academic research and acceptance within the larger community of policy makers, climate change has recently been a controversial subject matter within the tourism field and beyond. Shani and Arad (2014), for instance, presented a so-called "skeptic" view on climate change impacts to world economies. Therein, they criticized tourism scholars studying the implications of climate change on the global tourism industry by quoting a statement by Roy Spencer, another isolated climate scientist, stating that "extraordinary claims require extraordinary evidence" (2007). As a response to Shani and Arad (2014), Hall and his colleagues (2015) summarized the extant climate change literature by providing substantive evidence of the anticipated adverse impact of climate change. Hall, AmelungCohenEijgelaar, et al. (2015) and Hall, Amelung, et al. (2015), 17) further stated, "there is no shortage of recognition within the tourism industry that climate change is real …. There is substantial contestation over issues of adaptation, mitigation, vulnerability, and resilience. Such areas are where the debate should be focused."

In line with Hall, AmelungCohenEijgelaar, et al. (2015) and Hall, Amelung, et al. (2015), this research focuses on vulnerability and resilience assessments of the tourism industry. These two concepts are especially important when studying the human dimensions of climate change, which include culture, society and economics, and the environment (Brondizio & Moran, 2008; Janssen & Ostrom, 2006). Arguably, these facets are intertwined within the tourism industry facilitating the success of mitigation and adaptation strategies.

Mitigation and adaptation strategies vary according to the dimensions present at each specific location (Smit, Burton, Klein, & Street, 1999). In general, mitigation strategies include the enhancement, restoration, creation, or preservation of current standards in order to offset unavoidable impacts. In this case, the impacts are those of climate change. Adaptation strategies, on the other hand, are strategies aimed at altering the current standard to meet, and adapt to, the impacts of

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climate change. Adaptation to climate change in the tourism industry is thoroughly reviewed by Smit et al. (1999), and more recently by Scott, Gössling, and Michael Hall (2012). Adaptation strategies may become "maladaptive," however, if they are implemented without a comprehensive vulnerability and resilience assessment (Füssel & Hildén, 2014).

Vulnerability and resilience assessments summarize at-risk resources, as well as the strengths of a destination (e.g., country), in coping with severe climate change impacts (Füssel & Hildén, 2014; IPCC, 2007). Several researchers have proposed alternative models to assess destinations' vulnerability to climate change (Hyman, 2014; Neuvonen et al., 2015; Richardson and Witkowski 2010), with a critical analysis of the existing climate change vulnerability and resilience models by Watson, Iwamura and Butt (2013). There, they point out weaknesses in the existing models, arguing that vulnerability to climate change is addressed without non-climatic factors (e.g., social dimensions) and a sensitivity analysis. Further studies show the absorption of climate change impacts depends on non-climatic factors, such as social capital and the resources present in the locale (Adger 2000, 2009).

Omitted from previous research on vulnerability and resilience modeling, non-climatic factors are important indicators of an ecosystem's functions and health. For example, resource richness (i.e., number of resources available) can determine ecosystem stability. Communities rich in resources have greater stability than those without (Bloor & Bardgett, 2012; Roscher et al., 2013). Furthermore, the more resource types present, the higher the buffering capacity for extreme changes (Roscher et al., 2013; Yachi & Loreau, 1999). Resource richness and diversity are overlooked factors that affect a tourism destination's ability to adapt to and resist climatic changes. Further, increased stability alleviates stress on the tourism businesses themselves.

Without diverse economic, political, and social capital, even areas of high tourism may suffer from vulnerability and lack of resilience, especially to a force as widespread as climate change. As Füssel and Hildén (2014) put forward, "planned adaptation is driven by projected changes in climate, but, like any long-term planning, anticipated changes in other economic, political, and social factors also need to be considered." Therefore, vulnerability and resilience assessments should go beyond the projected changes in climatic factors and include economic, political, and social conditions (Dilling, Meaghan, William, Olga, & Roberta, 2015; Gössling, Scott, Michael Hall, Ceron, & Dubois, 2012; Ionescu et al., 2009; Polsky, Neff, & Yarnal, 2007).

Further, extant studies only provide vulnerability assessments that are qualitative in nature. Qualitative studies provide foundational information for future research and help to frame research questions, but without quantifying the effects of vulnerability and resilience on specific or general economic activities, mitigation and adaptation strategies may be less than perfect (Rutty et al., 2017; Watson, Iwamura & Butt, 2013). A systemic vulnerability and resilience assessment takes climatic *and* economic, social, and political factors into account, and also enables the quantification of the effects of climate change on tourism. Dogru, Bulut, and Sirakaya-Turk (2016) have presented a comprehensive vulnerability and resilience assessment that includes non-climatic factors and results in empirical evidence, showing the vulnerability and resilience of Mediterranean tourism to climate change. This study, however, was limited to Mediterranean countries, and the analyses omitted any comparisons of the vulnerability and resilience of tourism to other sectors of the economy.

As mentioned, tourism is considered to be one of the most vulnerable industries because of its dependence on climatic resources (IPCC, 2007). To the best of the authors' knowledge, however, there is no empirical evidence showing whether tourism is more or less vulnerable and resilient to climate change compared to other sectors of the economy. Thus, it is necessary to address these gaps and investigate the vulnerability and resilience of tourism to climate change. To do so, we (1) conceptualize a vulnerability and resilience framework, (2) empirically examine the effects of vulnerability and resilience on the tourism industry, and (3) compare the results with those of the worldwide economy. In so doing, we analyze the extent to which tourism is more or less vulnerable and resilient to climate change compared to the entire economy. The results of this study will enable us to determine if tourism stakeholders should be more or less concerned about the capacity of global tourism economies to resist the effects of climate change. We also investigate whether or not the vulnerabilities vary within different income tier countries; for this purpose, we divided our sample into low, middle, and high-income tier groups. The present paper aims to contribute to the growing body of climate change and tourism literature by assessing the overall tourism industry's vulnerability and the extent to which resilience factors help to reduce the adverse climate change impacts across the globe.

2. Literature review

The effects of climate change on tourism have been investigated through various approaches, with aims to assess its implications for the tourism industry across various geopolitical regions, countries, and cities (Gössling et al., 2012; Rosselló-Nadal, 2014; Rutty et al., 2017). Earlier studies have analyzed the effects of changes in climatic variables, such as temperature and precipitation, on tourism demand (Gómez Martín , 2005; Scott, McBoyle, & Schwartzentruber, 2004). Simulations were also used to investigate the impacts of climate change on tourist flows (see, e.g., Amelung & Nicholls, 2007; K. Smith, 1993). Findings from these previous studies show that climate change adversely affects the tourism industry. Specifically, they predict a downturn in tourism demand, suggesting that existing tourist destinations, such as coastal cities, island economies, and ski resorts, are expected to suffer from climate change in the near future (Belle & Bramwell, 2005; Berrittella, Bigano, Roson, Richard, & Tol, 2006; Breiling & Charamza, 1999; Neuvonen et al., 2015; Scott & McBoyle, 2007; Yang & Wan, 2010).

However, the relationship between climate change and tourism is more complex than what is depicted by models that solely use climate change scenarios to predict tourism demand and flows (Gössling et al., 2012). Relying on changes in climatic variables (e.g., temperature and precipitation) as proxies to assess the potential adverse climate change impacts on tourism is problematic because such analyses lack a theoretical foundation (Goh, 2012; Hernandez & Ryan, 2011). Without a theoretical foundation, the results of these models cannot be appropriately contextualized. In addition, these models fail to incorporate projected changes in economic, political, and social factors, which are of paramount importance in investigating climate change impacts (Ford et al., 2012; Janssen & Ostrom, 2006; Schroter et al., 2005; Shaw & Loomis, 2008). Developing mitigation and adaptation strategies without taking economic, political, and social dynamics into consideration may result in flawed outcomes (Füssel & Hildén, 2014).

Recently, developing mitigation and adaptation strategies has been one of the primary research areas of interest in tourism and climate change literature (see, e.g., Kaenzig, Rebetez, & Serquet, 2016; Schliephack & Dickinson, 2017). However, these strategies were offered *without* a vulnerability and resilience assessment for their particular destination. In Greece, Michailidou, Vlachokostas, and Moussiopoulos (2016) recommended using renewable energy, developing coastal setbacks, constructing dams, and increasing access to hybrid vehicles as alternative strategies to address climate change. Instead of using coastal setbacks, the island nation of Kiribati has purchased land in Fiji to move their nation and thus escape from adverse climate change impacts (Caramel, 2014). While seemingly impractical, moving an entire local population elsewhere could be more feasible than building coastal setbacks.

Studies of Dawson and Scott (2013); Scott (2006); Scott and McBoyle (2007); and Scott et al. (2012) showed that artificial snowmaking is a widely used strategy to cope with adverse impacts of snow loss due to climate change. Artificial snowmaking is an adaptation strategy for ski resorts that do not receive adequate, regular snowfall to

sustain the skiing season. Snowmaking, however, needs specific conditions, which may not be applicable to all ski resorts across the globe (Scott & McBoyle, 2007).

Certainly, the adverse impacts of climate change do motivate the adoption of both mitigation and adaptation strategies; however, no strategy is applicable to every destination. Rather, systemic vulnerability and resilience assessments determine the direction and the level of mitigation and adaptation policies needed in order to tackle the impacts of climate change (Dubois & Ceron, 2006; Smit, Burton, Richard, Klein, & Wandel, 2000; Smit & Wandel, 2006). Tourism destinations are likely to have different degrees of vulnerability and resilience, reflective of their different social, economic, and environmental conditions. This may make adaptation strategies, such as artificial snowmaking in the case of ski resorts, an unsustainable option (Rutty et al., 2017). Instead, physically relocating ski resorts to a different location (i.e., in a higher altitude) might be a better solution. The baseline requirement is that local conditions are understood before assessing the vulnerability and resilience of specific tourist destination, so that the assessment can aid the implementation of appropriate adaptation and mitigation strategies.

Overall, adaptation and mitigation strategies are likely to fail when vulnerability and resilience assessments are missing (Füssel & Hildén, 2014; Rutty et al., 2017). Therefore, the vulnerability and resilience of a country in general, or the tourism industry in particular, must be assessed *prior* to developing climate change mitigation and adaptation measures (Ford et al., 2012; Füssel & Hildén, 2014; IPCC, 2014). Fig. 1 illustrates a cyclical, systematic approach to investigate the potential impacts of climate change and develop feasible mitigation and adaptation strategies.

A systemic vulnerability and resilience assessment of a destination should be the starting point for decision-makers contemplating ways to address climate change impacts and develop mitigation and adaptation strategies (Dilling et al., 2015; Watson, Iwamura & Butt, 2013). A vulnerability and resilience assessment is a comprehensive process that includes projected changes not only in climatic variables but also in quality of life indicators (e.g., access to clean water, food, level of urbanization) and a country's resources to respond to climate change (e.g., level of economic, social, and political development). Previous research indicates concerns that vulnerability and resilience assessments are too narrow in scope (Ionescu et al., 2009; Luers et al., 2003; Polsky et al., 2007) and should focus on understanding *coupled* human–environment systems (Füssel, 2007; Polsky et al., 2007; Turner et al., 2003). While the quality of life indicators add to this, assessments should also use social variables (e.g., inequality, communication infrastructure) which help define the social system of the location under study.

Fig. 1.

Likewise, vulnerability assessments should be derived from multiple disciplines, as well as stakeholder participation (Schroter et al., 2005). Further, they should remain focused on the destination of concern, consider stressors from multiple, interacting sources, account for adaptive capacity, and be preventive rather than prescriptive (Schroter et al., 2005). Tourism is a complex, interconnected system (Miller & Twining-Ward, 2005), reliant upon a multitude of variables. Proper accounting of these variables is important for any model predicting tourism patterns and flows, with climate change variables adding another layer of complexity (Becken & Hay, 2007). In the remote coastal communities of Fiji, for example, sustainable tourism has become a focus for adapting to impacts stemming from climate change (Moreno & Becken, 2009). While coastal communities have been identified as among the most vulnerable (Moreno & Becken, 2009), all tourist destinations should consider assessing their vulnerability and resilience in order to build the capacity to adapt to a changing world.

The importance and extent of vulnerability and resilience assessments have recently been recognized; however, the extent to which vulnerability and resilience concurrently affect economic activities, wherein climate plays an indisputable and substantial role, is not clear. Essentially, climatic changes may affect overall economic activity, as well as that of tourism. For example, the detrimental effects of climate change include altering an area's accessibility, fragility, and diversity, among various other characteristics of an area.

Nyaupane and Chhetri (2009) have proposed a vulnerability assessment model for nature-based tourism that measures these facets, including the marginality and niche characteristics of a region. Studies by Moreno and Becken (2009) and Richardson (2010) have each presented an assessment framework used to examine a destination's vulnerability to climate change. Moreno and Brecken outline a five-step assessment, including a system analysis, the identification of activity and hazard subsystems, an individual vulnerability assessment for each subsystem at risk, integration, and communication. Richardson and Witowski (2010) propose an economic model to assess vulnerability to climate change, specifically in tourism-dependent nations.

Although a qualitative assessment of tourism's vulnerability to climate change is beneficial, the type of quantified vulnerability and resilience assessment that follows the steps in Fig. 1 is necessary to better understand the implications of climate change for the tourism industry. Further complicating assessments is the fact that vulnerability and resilience are not static, but rather may change over time. In fact, mitigation strategies are specifically aimed at changing vulnerability and adaptation (Dilling et al., 2015). Therefore, vulnerability and resilience must be quantified through a systematic data collection of relevant factors.

A quantified vulnerability and resilience assessment allows us to employ the second phase of the cycle in Fig. 1. That is, an examination of the effects of vulnerability and resilience on general or particular economic activities will determine the extent to which the factors included in the assessment affect economic activities. Otherwise, analyzing whether climate change affects the tourism industry or other general economic activities may not be conceivable. Destination management organizations (DMOs) and policy makers could further gauge whether adaptation and mitigation strategies developed based on such assessments actually help to reduce vulnerability and increase resilience. Therefore, conceptualizing and analyzing the vulnerability and resilience of tourism, an industry that is significantly affected by changes in both climatic and non-climatic factors (i.e., economic, social, and political features), is essential to developing feasible adaptation and mitigation strategies on a macro scale, and later micro scale, as depicted in steps four and five.

Previous studies, including one by Dogru et al. (2016), have conceptualized the relationship between climate change and tourism within a theoretical framework of vulnerability and empirically examined the effects of vulnerability and resilience on tourism demand. As mentioned, however, the sample of their study was geographically limited to countries in the Mediterranean Basin. In addition, vulnerability and resilience assessment indicators were limited to aggregate-level data. This example illustrates that data are not always reliable, consistent, comparable, or feasible to obtain (Füssel & Hildén, 2014), and that assessments should be as comprehensive as possible and based on reliable, consistent, and comparable data that are feasible to obtain. Furthermore, climate change is likely to have varying outcomes depending on a country's ability to cope with the potential consequences of climate change (Hinkel et al., 2014; Mycoo 2014, 2017). Dogru et al. (2016), however, did not examine the extent to which the vulnerability and resilience of the tourism industry to climate change varies across countries based on their economic development. In the present study, this question is explored quantitatively.

Previous research has suggested that tourism is less resilient and more vulnerable to climate change than all other sectors of the economy, *combined* (Dogru et al., 2016; IPCC, 2007). However, to date, there is no empirical evidence to back this claim. Our study builds on the conceptual model presented by Dogru et al. (2016) and attempts to fill its voids in assessing the vulnerability and resilience of tourism to climate change.

3. Theoretical framework and hypotheses development

An assessment of the vulnerability of the tourism industry to climate change is a comprehensive and systemic process that involves exposure, sensitivity, and capacity assessments of other fundamental, life-supporting sectors (Füssel & Hildén, 2014). In general, these sectors include health, food, ecosystem, human habitat, water, and infrastructure. These sectors' exposure to climate change, the sensitivity of these sectors to climatic conditions, and their adaptive capacities to cope with adverse impacts of climate change together help determine the overall vulnerability to climate change (Ionescu et al., 2009).

Projected changes in these life-supporting sectors indicate a country's exposure level (Füssel, 2007). The extent to which the sectors depend on the climate determines their sensitivities (Füssel & Klein, 2006, p. 314). While the sectors might be exposed to climate change and sensitive to climatic conditions, they also have inherent strengths and adaptive capacities that help them endure climate change-related hazards. The sectors' ability to adjust or cope with the consequences of climate change without direct interference or policy execution determines countries' adaptive capacities (IPCC, 2007; Smit et al., 2000).

Changes in a country's food and water supplies are considered to be due to the changes in climatic conditions, and hence, declines in the supplies of food and water both indicate and increase that country's vulnerability to climate change (Rosenzweig et al., 2013). Dependence on imported foods and water resources controlled by foreign governments, poor health conditions and insufficient health professionals, deteriorating biome and marine biodiversity, and dependence on ecosystem services also make destinations more vulnerable to climate change (Rizvi, Baig, and Verdone 2015). The frequency of extreme weather events, such as storms, flooding, landslides, heat waves, and other disastrous events, as well as the quality of infrastructure, are also utilized to assess a country's vulnerability to climate change (Füssel & Hildén, 2014). In particular, agricultural capacity, food import dependency, and the population of residents living in rural areas projected change in precipitation, population with access to improved water supply, and internal and external fresh water are some of the food and water sectors' vulnerability indicators (Ionescu et al., 2009; ND-GAIN, 2014).

Access to improved sanitation facilities, dependency on external resources for health services, and access to improved sanitation facilities are examples of health sector vulnerability components (ND-GAIN, 2014). Excess urban growth, threaten species, dependency on natural capital, a population living less than 5 m above the sea level, and population with access to reliable electricity are some of the elements used to assess human habitat, ecosystem, and infrastructure sectors' vulnerabilities to climate change (Polsky et al., 2007).

Although vulnerability to climate change is a comprehensive assessment, it is merely an exploratory analysis that shows "the degree to which a country is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes" (IPCC, 2007, p. 5). While vulnerability to climate change is expected to adversely affect economic activities, whether or not vulnerability to climate change affects overall versus particular economic activities is not clear. Nevertheless, the extent to which vulnerability to climate change affects overall or particular economic activities must be examined to inform decision-makers about mitigation and adaptation strategies that need to be developed as policy responses to climate change (Ionescu et al., 2009; Kelly & Adger, 2000). Based on the vulnerability theory and the relevant literature, we postulate that higher vulnerabilities of health, food, ecosystem, human habitat, water, and infrastructure resources suggest generally higher vulnerability to climate change, and thus, both the tourism industry and economic activities are expected to be adversely affected (Fig. 2). The following hypotheses are proposed to test these postulations.

H1. Vulnerability to climate change adversely affects tourism receipts.

H2. Vulnerability to climate change adversely affects the gross domestic product.

Similar to an assessment of vulnerability to climate change, one covering resilience to climate change is also comprehensive and systematic, and it should indicate ways for a country to successfully absorb additional private sector investments and apply them effectively towards increasing resilience to climate change and other global challenges (Füssel & Hildén, 2014; Ionescu et al., 2009; Kelly & Adger, 2000; ND-GAIN, 2017). The economic environment, political stability, and social conditions of a country determine its resilience to climate change, because these factors affect the ability to undertake necessary actions and make investments to implement climate change adaptation and mitigation strategies. Economic, social, and political resiliencies are assessed using quantifiable proxies, such as government spending, trade freedom, corruption, violence, education, and rule of law (ND-GAIN, 2014).

Coping with severe climate change impacts may require substantial capital investments. Thus, economic conditions are a crucial part of implementing mitigation and adaptation strategies. More specifically, economic freedom indicates a country's economic resilience in responding to climate change-related hazards. The concept of economic freedom comes from Adam Smith's seminal book, *The Wealth of Nations* (A. Smith & McCulloch, 1776). In accordance with Adam Smith's economic theory, the *Wall Street Journal* and the Heritage Foundation developed an economic freedom index, which is commonly used to assess countries' economic resilience in terms of coping with climate change impacts, and which measures variables including liberty, prosperity, and business, trade, fiscal, and freedom. The Heritage Foundation further elucidates: "In economically free societies, governments allow labor, capital and goods to move freely, and refrain from coercion or constraint of liberty beyond the extent necessary to protect and maintain liberty itself" (2013), which is essential to attracting domestic and foreign investments needed to implement adaptation and mitigation strategies.

While economic resilience is of paramount importance in responding to climate change, political and social resiliencies also play a major role in developing mitigation and adaptation policies. Social resilience is the ability of people and institutions to effectively cope with both local and global challenges (Füssel & Hildén, 2014). The degree of

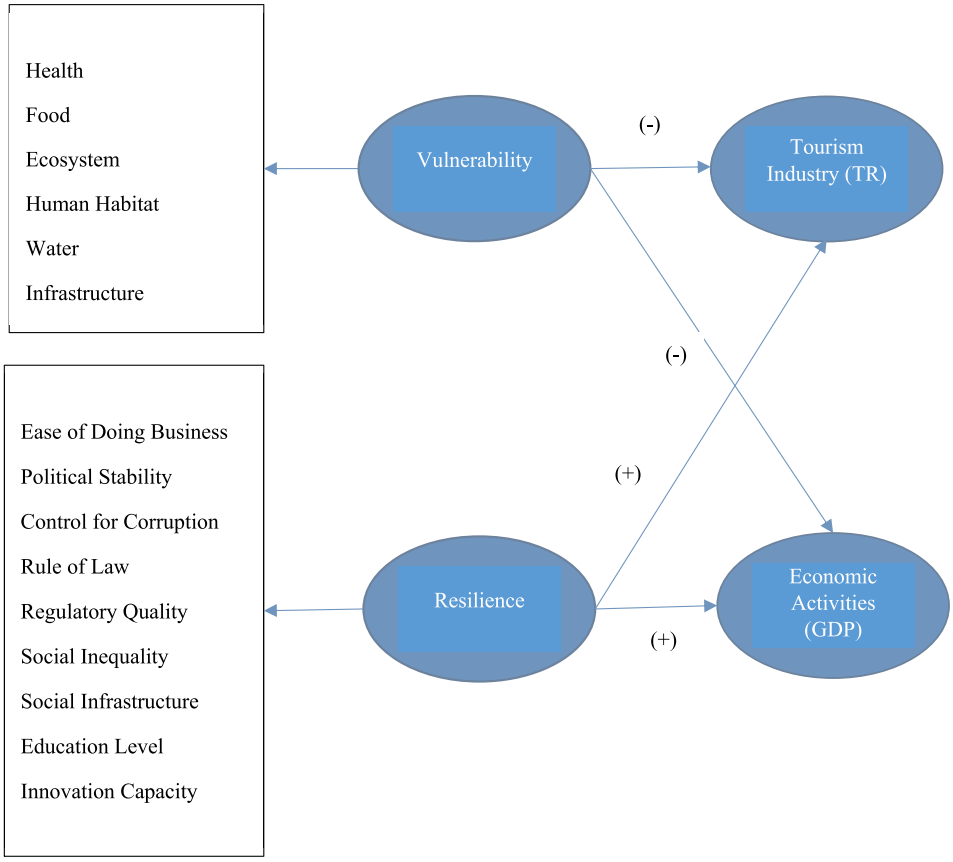

Fig. 2.

inequality, education level, communication infrastructure, and capacity for technology and innovation all inform a country's social resilience. Political resilience is the "capacity of the government to effectively formulate and implement actionable policies; and the respect of citizens and the state for the institutions that govern economic and social interactions among them" (Kaufmann, Kraay, & Mastruzzi, 2011, p. 2). An unstable political environment, coupled with poor governance mechanisms and corruption, would make investments undesirable for both domestic and foreign firms. Thus, both political and social resiliencies play crucial roles in developing mitigation and adaptation strategies to tackle the impacts of climate change.

Once economic, political, and social resiliencies are determined, the extent to which resilience to climate change affects overall or particular economic activities must be examined to inform stakeholders about the essential focus areas to develop mitigation and adaptation strategies (Ionescu et al., 2009). Therefore, based on the literature, we postulate that higher economic, political, and social resiliencies suggest higher resilience to climate change specifically. That is, countries with better regulatory quality, economic freedom, education level, political stability, control for corruption, rule of law, and innovation capacity are expected to better cope with adverse climate change impacts. The tourism industry and other general economic activities subsequently are expected to be positively affected by an increased degree of resilience to climate change (Fig. 2). The following hypotheses are offered to test these postulations.

H3. Resilience to climate change positively affects tourism receipts.

H4. Resilience to climate change positively affects the gross domestic product.

Anticipated changes in climatic factors are projected to adversely affect current destinations, as weather, temperature, and climate factors influence tourists' destination preferences, destination images, and the general tourism demand (Bujosa et al., 2015; Gómez Martín , 2005). Consequently, the tourism industry is considered to be one of the most vulnerable and least resilient to severe climate change impacts, compared to other sectors of the economy (Dogru et al., 2016; IPCC, 2007; Hall, Amelung, Cohen, Eijgelaar, Gössling, Higham, et al., 2015; Rosselló-Nadal, 2014). Considering the importance of the climate and life-supporting features embedded within the supply chain of the tourism industry, hypothesizing higher vulnerability and lower resilience of tourism to climate change is plausible. However, to date, there is no empirical evidence indicating whether tourism is more or less vulnerable to climate change, compared to other sectors of the economy. Thus, we offer the following hypotheses to test these postulations.

H5. The effects of vulnerability on tourism receipts will be greater than the effects of vulnerability on gross domestic product.

H6. The effects of resilience on tourism receipts will be lower than the effects of resilience on gross domestic product.

Furthermore, climate change is likely to have varying outcomes, depending on how heavily countries rely on the climate in their economies and how their economic, political, and social environments equip them to cope with potential consequences of climate change (Gómez Martín , 2005; Ionescu et al., 2009). While developed—and perhaps some developing—countries can allocate economic resources to implement engineered adaptation and mitigation policies, less developed countries are less likely to develop such policies to tackle climate change issues due to their scarce resources (IPCC, 2014; Schliephack & Dickinson, 2017). Paradoxically, less developed countries primarily depend on the tourism industry in their economies (Shakeela & Becken, 2015). These destinations might lose their shape, attractiveness, and popularity through adverse changes in climatic factors.

As a result, policy makers in less developed countries might encounter both current to long-term problems in dealing with the impacts of climate change. Hence, less developed countries are said to be more vulnerable and less resilient to climate change, mainly because these countries already have scarce resources and also primarily rely on climate-sensitive economic sectors, such as agriculture and tourism (Dillimono & Dickinson, 2015).

Destinations with better economic conditions will be more prepared to cope with severe climate change impacts, compared to those with worse economic conditions (Michailidou et al., 2016). Therefore, the consequences of climate change are likely to vary based on a country's resources. Nevertheless, this has not been empirically tested in the context of vulnerability and resilience frameworks. Therefore, we postulate the following hypotheses to test whether or not the effects of vulnerabilities and resiliencies vary within different income tier countries, in which we have divided our sample into high, middle, and low-income tier groups.

H7. The effects of vulnerability on tourism receipts will be greater in low-income tier countries compared to those of high-income tier countries.

H8. The effects of resilience on tourism receipts will be lower in low-income tier counties compared to those of high-income tier countries.

4. Methodology

4.1. Model specification

The dependent variables of the present study are tourism receipts (TR) and gross domestic product (GDP), and the independent variables are vulnerability to climate change (VUL) and resilience to climate change (RES). We first examined the extent to which vulnerability to climate change and resilience to climate change affect the tourism industry and overall economy, where TR and GDP are described as functions of vulnerability and resilience. The empirical models are specified as follows:

$$lnTR_{it} = \alpha_{0i} + \alpha_{1i} VUL_{it} + \alpha_{2i} RES_{it} + \varepsilon_{it} \quad (1)$$

$$lnGDP_{it} = \delta_{0i} + \delta_{1i} VUL_{it} + \delta_{2i} RES_{it} + \varepsilon_{it} \quad (2)$$

where lnTR, lnGDP, VUL, RES, and ε stand for natural logarithmic forms of tourism receipts, natural logarithmic forms of real GDP, vulnerability to climate change, resilience to climate change, and the error term, respectively.

Furthermore, in order for countries to develop appropriate policy responses to severe climate change impacts, it is important to analyze and understand the distinctive effects of vulnerability and resilience indicators. While examining the effects of vulnerability and resilience constructs on a country's tourism industry and overall economy may elucidate theoretical implications, managerial and policy implications of such analysis will be limited. Therefore, we further explored the extent to which indicators that constitute the vulnerability and resilience constructs affect the tourism industry and overall economy. That is, TR and GDP are modeled as functions of health, food, ecosystems, human habitat, water, infrastructure, ease of doing business, political stability and nonviolence, control for corruption, rule of law, regulatory quality, social inequality, information and communication technology infrastructure or social infrastructure, education level, and innovation capacity. The empirical models are specified as follows:

$$\begin{aligned} lnTR_{it} = {} & \beta_{0i} + \beta_{1i} HEALTH_{it} + \beta_{2i} FOOD_{it} + \beta_{3i} ECOS_{it} + \beta_{4i} HUMAN_{it} \\ & + \beta_{5i} WATER_{it} + \beta_{6i} INFRA_{it} + \beta_{7i} EASE_{it} + \beta_{8i} POL_{it} + \beta_{9i} COR_{it} \\ & + \beta_{10i} RULE_{it} + \beta_{11i} REG_{it} + \beta_{12i} INEQ_{it} + \beta_{13i} SOCINFRA_{it} \\ & + \beta_{14i} EDU_{it} + \beta_{15i} INNOV_{it} + \varepsilon_{it} \end{aligned} \quad (3)$$

$$\begin{aligned} lnGDP_{it} = {} & \lambda_{0i} + \lambda_{1i} HEALTH_{it} + \lambda_{2i} FOOD_{it} + \lambda_{3i} ECOS_{it} + \lambda_{4i} HUMAN_{it} \\ & + \lambda_{5i} WATER_{it} + \lambda_{6i} INFRA_{it} + \lambda_{7i} EASE_{it} + \lambda_{8i} POL_{it} \\ & + \lambda_{9i} COR_{it} + \lambda_{10i} RULE_{it} + \lambda_{11i} REG_{it} + \lambda_{12i} INEQ_{it} \\ & + \lambda_{13i} SOCINFRA_{it} + \lambda_{14i} EDU_{it} + \lambda_{15i} INNOV_{it} + \varepsilon_{it} \end{aligned} \quad (4)$$

where HEALTH, FOOD, ECOS, HUMAN, WATER, INFRA, EASE, POL, COR, RULE, REG, INEQ, INFRA, INNOV, POL, REG, RULE, SOCINFRA, EDU, and INNOV stand for vulnerabilities of health, food, ecosystems, human habitat, water, infrastructure, ease of doing business, political stability and nonviolence, corruption control, the rule of law, quality of regulation, social inequality, information and communication technology infrastructure or social infrastructure, education level, and innovation capacity.

4.2. Sample and data

Tourism receipts (TR) and Gross Domestic Product (GDP) data were obtained from the World Bank database online (The World Bank, 2017). Data on vulnerability and resilience constructs, along with the variables that constitute these constructs, were obtained from the Notre Dame Global Adaptation Institute (ND-GAIN) online, which is a part of the Climate Change Adaptation Program of the University of Notre Dame Environmental Change Initiative (ND-GAIN, 2017). The ND-GAIN generates the ND-GAIN Index using climate change vulnerability and resilience constructs to measure these in different countries.

The ND-GAIN dataset fit the study best for four reasons. First, ND-GAIN is a nonprofit institution that constructs this dataset by "surveying the most recent climate change literature and consulting scholars, adaptation practitioners, and global development experts" (Chen, NobleHellmannCoffeeMurillo, & Chawla, 2015, p. 5). Second, ND-GAIN's vulnerability and resilience measures are the most comprehensive dataset available, consisting of indicators that are freely accessible by the public and available for the majority of the countries in the world. Third, the dataset contains reliable and transparent indicators collected and maintained by trustworthy organizations. Finally, the dataset is in the form of time series, which dates back to 1995 and extends to the most recent available year, which allows for tracking trends throughout the years and other more sophisticated forms of analysis, such as time series and panel data analysis.

Furthermore, this is the only dataset, to the best of the authors' knowledge, available at a macro level that allows for the examination of vulnerabilities and resiliencies within the tourism industry and other economic activities. Although the dataset is briefly explained in this study, ND-GAIN's methodology in developing the vulnerability and resilience constructs are much more detailed. Hence, we strongly encourage readers to view the technical report for an extensive description of its methodology and justification of variables, which is available on the ND-GAIN's website.

The sample of this study consists of countries that have annual TR and GDP data available on the World Bank database and ND-GAIN measures of vulnerability and resilience for the period of 1995–2014, which comprises the full extent of database records available. The observations with missing variables were removed from the analysis. Accordingly, the final sample—which is essentially the census of this study—consists of 1800 country-year observations with 90 countries. The list of countries included in the sample can be found in the appendix.

4.3. Empirical approach

Arellano and Bond (1991) developed a generalized method of moments (GMM) estimator that deals with biased and inefficient estimates in dynamic panel data models (Baltagi, 2008). A dynamic panel data model with regressors can be illustrated as follows (Greene, 2003).

$$y_{it} = \alpha y_{i,t-1} + \beta x_{it} + \delta_i + \varepsilon_{it} \quad (5)$$

In order to eliminate individual effects, Arellano and Bond (1991) use the first difference form of Equation (5)

$$y_{it} - y_{i,t-1} = \alpha(y_{i,t-1} - y_{i,t-2}) + \beta(x_{it} - x_{i,t-1}) + (\delta_i - \delta_i) + (\varepsilon_{it} - \varepsilon_{i,t-1}) \quad (6)$$

$$\Delta y_{it} = \alpha \Delta y_{i,t-1} + \beta \Delta x_{it} + (\varepsilon_{it} - \varepsilon_{i,t-1}) \quad (7)$$

As illustrated, individual effects are removed. However, $y_{i,t-1}$ is correlated with $\varepsilon_{i,it-1}$, and the error term $(\varepsilon_{it} - \varepsilon_{i,t-1})$ is MA (1) with unit root as well (Baltagi, 2008). Arellano and Bond (1991) propound two-stage instrumental variables to solve these problems. Therefore, the analyses have been conducted by utilizing the first-difference generalized methods of moments (GMM) panel estimator developed by Arellano and Bond (1991) to account for possible endogeneity problems that may arise due to unobservable effects and to eliminate country-specific heterogeneity in the model.

While the panel GMM estimator does not require the error terms to be normally distributed, the error terms must be free of serial correlation (Arellano & Bond, 1991). Therefore, the second order, *AR(2)* serial correlations, which contains the null hypotheses of no serial correlations, must be tested. Arellano and Bond (1991) also suggest that the validity of instrumental variables should be tested via Sargan (1958) test. Thus, we examined the validity of instrumental variables utilizing Sargan (1958) test, which is the most common test used to analyze the validity of instrumental variables.

5. Hypotheses testing and empirical results

This section presents the results from the multivariate analyses examining the extent to which the vulnerability and resilience to climate change affect the tourism industry and the overall economy of different countries. We first examined the effects of vulnerability and resilience to climate change on tourism receipts and gross domestic products for all countries included in the sample of this study. Table 1 reports these findings.

Prior to interpreting the coefficient estimates, instrumental validity and serial correlations were examined. We applied the Sargan (1958) test, and the results suggest that the instrumental variables are valid. That is, instrumental variables are properly selected in the models. Furthermore, the second order, *AR(2)*, serial correlation test are utilized following Arellano and Bond (1991). According to the results, the error terms have no serial correlations, and thus coefficient estimates can be interpreted.

In column 1 of Table 1, where the dependent variable is tourism receipts (TR), the results show that the coefficients of vulnerability to climate change (VUL) (-9.043, $p < 0.01$) and resilience to climate change (RES) (0.735, $p < 0.01$) are statistically significant. These results support our hypotheses H1 and H3, which we proposed based on the vulnerability theoretical framework and relevant literature, and which suggested that while vulnerability to climate change has an adverse impact on tourism receipts, resilience to climate change has a positive effect on tourism receipts.

We also analyzed the extent to which vulnerability and resilience to climate change affect the gross domestic product, as a means to compare whether the tourism industry, specifically, is more or less vulnerable and resilient to severe climate change impacts. Column 2 of Table 1 reports these results and illustrates that coefficients of vulnerability to climate change (VUL) (-6.134, $p < 0.01$) and resilience to climate change (RES) (0.724, $p < 0.01$) are statistically significant. These findings support the hypotheses H2 and H4, based on the vulnerability theoretical framework and the relevant climate change literature. That is, vulnerability to climate change adversely affects the overall economy, while resilience to climate change has a positive effect on the economy.

These results support the postulations from previous research that tourism is not the only industry that will face negative effects from climate change (IPCC, 2007; Hall, Amelung, Cohen, Eijgelaar, Gössling, Higham, et al., 2015). Nevertheless, tourism is also considered to be one of the most vulnerable industries because of its singular dependence on climatic resources. However, there is no empirical evidence to show whether or not tourism is actually more vulnerable and less resilient to climate change. The coefficients of VUL from columns 1 and 2 of Table 1 clearly show that vulnerability to climate change affects tourism industry more than it affects the overall economy (TR: -9.043 vs. GDP: -6.134), and the coefficient difference test shows that this difference is statistically significant ($t = 22.98$; $p < 0.01$). While these results support our hypothesis (H5) favorably, they fail to corroborate the hypothesis (H6), which postulated that the effects of resilience on tourism receipts will be lower than the effects of resilience on gross domestic product. That is, the tourism industry, albeit more vulnerable, appears to also be more resilient to climate change compared to other sectors of the economy.

In addition to the effects of vulnerability and resilience to climate change on tourism and the entire economy, we further examined the effects of indicators that constitute vulnerability (e.g., health, food, and ecosystems) and resilience (e.g., ease of doing business, political stability and non-violence, and control for corruption) on tourism receipts and the gross domestic product for all countries included in the sample of this study. Table 2 reports these findings.

In both columns 1 and 2 of Table 2, where the dependent variables are tourism receipts (TR) and the gross domestic product (GDP) respectively, the results show that coefficients of health, food, ecosystems, human habitat, water, and infrastructure sectors' vulnerabilities are statistically significant and are aligned with our predictions, with the exception of vulnerability in infrastructure. Although we postulated that the vulnerability of a country's infrastructure will have an adverse impact on tourism and overall economic activities, the results provide contrary evidence suggesting that this vulnerability is positively associated with both tourism and the entire economy. However, the coefficients of health, food, ecosystems, human habitat, and water suggest that with the increased vulnerabilities of these life-supporting sectors, both the tourism industry and the overall economy are adversely affected. It is also evident that the impacts of these life-supporting sectors' vulnerabilities on the tourism industry are greater than those on the overall economy, which adds further support to the conjecture that tourism ultimately is more vulnerable to severe climate change impacts.

The results also show that the coefficients of the variables that constitute resilience are in line with our predictions, with few exceptions. Specifically, political stability and non-violence, control for corruption, rule of law, regulatory quality, information and communication technology infrastructure or social infrastructure, and education level positively affect tourism receipts, suggesting that, with increased resiliencies in these economic, political, and social factors, the tourism industry becomes more resilient to adverse climate change impacts.

In column 2 of Table 2, in which the GDP is the dependent variable,

Table 1
The effects of vulnerability and resilience on Tourism Receipts (TR) vs. Gross Domestic Product (GDP).

Variable	Dependent variable: lnTR		Dependent variable: lnGDP	
	Coefficient	Prob. value	Coefficient	Prob. value
VUL	−9.043[a]	0.000	−6.134[a]	0.000
RES	0.735[a]	0.000	0.724[a]	0.000
AR (2)[b]	0.213	0.830	−1.159	0.246
Sargan[c]	90.974	0.392	90.240	0.413

[a] Illustrates 1% statistical significance.
[b] AR (2) is the Arellano and Bond (1991) test used for detecting autocorrelation.
[c] Sargan test refers to the validity of the instrumental variables.

Table 2
The effects of vulnerability and resilience indicators on TR vs. GDP.

Variable	Dependent variable: lnTR		Dependent variable: lnGDP	
	Coefficient	Prob. value	Coefficient	Prob. value
COR	0.051[a]	0.000	−0.015	0.326
EASE	−0.482[a]	0.000	−0.205[a]	0.000
ECOS	−4.726[a]	0.000	−3.310[a]	0.000
EDU	0.002[b]	0.026	0.001[a]	0.000
FOOD	−0.583[a]	0.000	−0.481[a]	0.000
HEALTH	−1.148[a]	0.000	−0.766[a]	0.000
HUMAN	−2.444[a]	0.000	−1.346[a]	0.000
INEQ	0.014[a]	0.000	0.038[a]	0.000
INFRA	1.497[a]	0.000	1.332[a]	0.000
INNOV	−78.074	0.195	−55.915	0.447
POL	0.033[a]	0.000	−0.003	0.732
REG	0.133[a]	0.000	−0.046[b]	0.011
RULE	0.054	0.186	0.103[a]	0.000
SOCINFRA	1.049[a]	0.000	0.348[a]	0.000
WATER	−0.865	0.401	−1.439[a]	0.000
AR (2)[c]	0.004	0.996	−0.040	0.968
Sargan[d]	87.083	0.142	24.415	1.000

[a] Illustrates 1% statistical significance.
[b] Illustrates 5% statistical significance.
[c] AR (2) is the Arellano and Bond (1991) test used for detecting autocorrelation.
[d] Sargan test refers to the validity of the instrumental variables.

the coefficients of the variables that constitute the resilience construct yield even more complex results. In line with the results from column 1 of Table 2, the rule of law, information and communication technology infrastructure or social infrastructure, and education level positively affect the GDP, whereas the ease of doing business, social inequality, and innovation capacity yield evidence contradicting our postulations. While political stability, non-violence and control for corruption, albeit statistically insignificant, have negative effects on the GDP. The negative effect regulatory quality indicators on the GDP; however, is statistically significant.

These analyses examine the effects of vulnerability and resilience to climate change on tourism receipts and gross domestic product for the whole sample. However, the impacts of climate change on the tourism industry is expected to vary across countries and destinations depending on their economic development (Gómez Martín , 2005; Ionescu et al., 2009). Although economically advanced countries could better allocate more plentiful economic resources to implement mitigation and adaptation strategies in response to climate change impacts, such actions might be less feasible in countries with lower per capita income due to scarcer resources (Hinkel, van Vuuren, Nicholls, & Klein, 2013; IPCC, 2014; Mycoo, 2014; Mycoo, 2017; Schliephack & Dickinson, 2017; Shakeela & Becken, 2015).

Thus, we further examined the effects of vulnerability and resilience to climate change by dividing our sample into low, middle, and high income tier country categories. More specifically, we classified the countries in the sample into three groups based on their GDP per capita in 2014. The first group includes 30 countries with lowest GDP per capita in 2014, the second group comprises 30 countries in the middle based on GDP per capita in 2014, and the third group includes the countries with the highest GDP per capita in 2014. Table 3 presents these findings.

The coefficients of vulnerability and resilience to climate change are statistically significant at a 1% statistical significance level for all income tier categories, which corroborates our hypotheses. The results reveal that the effects of vulnerability to climate change vary across different income tier countries. In particular, countries with lower incomes are more vulnerable (VUL: −12.700) and less resilient (RES: 0.504) to climate change, whereas the countries with the highest income are less vulnerable (VUL: −4.083) and more resilient (RES: 1.259) to climate change. These results support our hypotheses (H7 and H8) that the effects of vulnerability and resilience to climate change on tourism receipts will be greater ($t = 6.83$; $p < 0.01$) and lower ($t = 6.43$; $p < 0.01$), respectively, in low income tier countries versus high income tier countries. Ultimately, vulnerability to climate change reduces tourism receipts regardless of the income tiers; however, this effect is much larger in middle and especially low income tier countries. Furthermore, high income tier countries are better prepared to cope with adverse impact of climate change and thus are able to increase tourism receipts through their stronger resilience to climate change.

Table 3
The effects of vulnerability and resilience on TR: Low, middle, and high income tier countries.

Variable	Low Income		Middle Income		High Income	
	Coefficient	Prob. value	Coefficient	Prob. value	Coefficient	Prob. value
VUL	−12.700[a]	0.000	−5.997[a]	0.000	−4.083[a]	0.000
RES	0.504[a]	0.000	0.858[a]	0.000	1.259[a]	0.000
AR (2)[b]	0.001	0.999	−1.156	0.247	−0.474	0.634
Sargan[c]	27.418	0.549	29.890	0.319	21.688	0.832

[a] Illustrates 1% statistical significance.
[b] AR (2) is the Arellano and Bond (1991) test used for detecting autocorrelation.
[c] Sargan test refers to the validity of the instrumental variables.

6. Discussion and conclusions

Growth in tourism is highly desired, especially by countries that heavily depend on the tourism industry in their economies (Dogru & Bulut, 2018). However, tourism development cannot be achieved and sustained without natural resources, the availability and abundance of which vary throughout the world. Unilaterally, climate change affects natural resources, such as food, water, forestry, and other life-supporting sectors; by extension, it affects the industries that rely on these to thrive, including tourism. Thus, analyzing adverse impacts of climate change, particularly vis-a-vis these life-supporting sectors, has been at the core of tourism literature in recent decades (Hall, Amelung, Cohen, Eijgelaar, Gössling, Higham, et al., 2015), as deteriorations in natural capital due to the changing climate patterns might have negative impacts on tourism growth and sustainable development. Extant studies have mainly focused on forecasting changes in climatic variables based on simulations and developing adaptation and mitigation strategies (Berrittella et al., 2006; Michailidou et al., 2016). However, these climate change scenarios do not take non-climatic factors, such as quality of life indicators, agricultural capacity, urban and rural population, longevity, threaten species, dependency on natural capital, as well as economic, social, and political factors into consideration. Such a gap in the literature calls for a comprehensive vulnerability and resilience assessment.

Vulnerability and resilience assessments can be interpreted as availability of “resource capital”. Akin to social capital, or the “goodwill that is engendered by the fabric of social relations and that can be mobilized to facilitate action” (Adler, 2002), resource capital is defined here as the diversity of natural resources available to a locale for robust, economic means. Low resource availability, including economic resource diversity, acts as an economic monoculture. Without diverse economic resources, even areas of high tourism may suffer from vulnerability and lack of resilience to change, especially change as widespread as climate change. To anticipate, withstand, and recover from change depends on access to varying forms of capital, including natural, economic, social and political capital (Calgaro & Lloyd, 2008). Although the importance of vulnerability and resilience assessment has been greatly recognized in climate change literature (Downing and Patwardhan 2004; Füssel, 2007; Kelly & Adger, 2000), vulnerability

assessment of tourism and its resilience to severe climate change impacts have not been widely investigated in the tourism literature. In view of these limitations, the present study examined the extent to which the level of vulnerability affects a country's overall economy or its tourism sector within the context of a vulnerability theoretical framework.

The results of our empirical examinations, intended to provide such an assessment, show that the tourism industry is highly vulnerable to climate change; but they also show that it displays adequate resilience to cope with severe climate change impacts. However, the effects of vulnerability to climate change are much greater than those of resilience to climate change. These results highlight the necessity of mitigation policies to reduce adverse climate change factors like greenhouse gas emissions and hence decrease destinations' vulnerability to climate change. Undeniably, additional adaptation policies will increase a country's resilience to climate change; however, these outcomes underline the risk level reached within the current circumstances that climate has already changed and the vulnerability has reached to a level that requires immediate attention.

Further examination of the effects of vulnerability and resilience on the entire economy shows that it too is vulnerable to climate change, with some resilience by which to cope with adverse climate change impacts. The results also show that the tourism industry specifically is more vulnerable to climate change than the entire economy, whereas they are both equally resilient. This means that while a country's resilience may not diverge across industries, an industry's vulnerability to climate change may vary greatly based on its dependence on natural and climatic resources. Therefore, severe climate change impacts to basic element of life and environmental conditions affect tourism more than overall economy combined because wellbeing of destinations plays significant role among tourists (Gómez Martín , 2005).

We also examined the tourism industry's vulnerability and resilience to climate change of across countries based on their level of economic development. While some destinations face similar changes in certain climatic factors, the adverse impacts of climate change are likely to be different across locations (Michailidou et al., 2016). That is, destinations with higher resilience through their social, economic, political, and social infrastructures will be better prepared to cope with climate change impacts, compared to those with poor resilience indicators. Therefore, the vulnerability and resilience of the tourism industry, as well as the consequences of climate change, are likely to vary based on a country's economic development (Shaw & Loomis, 2008). For example, less developed countries, small island nations, and hot and arid African countries are more sensitive to climate change because of their heavy dependence on agriculture and tourism in their economies (Kilungu, Leemans, Pantaleo, Munishi, & Amelung, 2017; Lysann Schneider and Haller 2017; Ofoegbu, Chirwa, Francis, & Babalola, 2017; Schmutter, Nash, and Dovey 2017).

In line with our original conjectures, we found evidence that the tourism industry's vulnerability and resilience to climate change greatly varies: countries with the lowest income levels are more vulnerable and less resilient, and those with highest income are the least vulnerable and most resilient, to climate change. The results of the present study, which succinctly quantify the vulnerability and resilience of the tourism industry specifically and the overall economy, have important theoretical and practical implications for industry leaders and policy makers.

6.1. Theoretical implications

From a theoretical perspective, the current study makes a key contribution to the limited empirical literature on the effects of vulnerability and resilience to climate change on the tourism industry. Specifically, we have argued that a systematic and comprehensive vulnerability and resilience assessment that includes both climatic and non-climatic factors is necessary to develop effective climate change mitigation and adaptation strategies. Vulnerability and resilience determine the underpinnings and the extent of the mitigation and adaptation policies required to tackle climate change impacts for a given country (Füssel & Hildén, 2014).

While mitigation works to reduce the current and future effects of climate change, adaptation restructures economic models under a “new normal.” Implementing both mitigation and adaptation policies will aid in increasing the resilience of tourism and other economic activities (Adger, 2009; Cheer & Lew, 2018; Hashemi, Bagheri, and Marshall 2017). Although analyzing projected changes in climatic variables is essential in developing mitigation strategies (Ionescu et al., 2009), current vulnerability and resilience assessments of non-climatic factors are also needed to develop appropriate adaptation and mitigation strategies. Otherwise, proposed mitigation and adaptation strategies do not go beyond speculation, because a one-size-fits-all approach to implementing mitigation and adaptation strategies might be counterproductive. Certain destinations have limited resources, so quantified vulnerability and resilience assessments allow for the identification of crucial focal elements that will most effectively combat severe climate change impacts.

Moreover, much existing research on vulnerability to climate change is limited in its inferential, temporal, and/or geographical scope. In this regard, the present study advances the site-scale qualitative vulnerability assessments (see, e.g., Moreno & Becken, 2009; Nyaupane & Chhetri, 2009; Richardson & Witkowski, 2010) by proposing an analytical framework that clarifies the effects of climate change on tourism and empirically analyzing these effects on the industry across the globe. These analyses corroborate the previously unverified popular conjecture that tourism is more vulnerable to climate change than overall economy.

Lastly, the degree of vulnerability and resilience is not homogenous among the countries, suggesting that vulnerability and resilience to climate change may vary based on economic development. We also provide empirical evidence showing that less developed countries are more vulnerable and less resilient to climate change, compared to developed economies. In so doing, the present study substantiates the theoretical postulations that the degree of vulnerability and resilience is not homogenous among the countries.

6.2. Practical implications

The findings of this study have important implications for both tourism destinations and policy makers alike. As the findings demonstrate, both the tourism industry and the entire economy are vulnerable to climate change. Our results also show that tourism is more vulnerable to climate change than the overall economy. Therefore, tourism stakeholders should be the proponents of policy development, push for adaptation and mitigation, and be pioneers of any resultant policy actions. Further, creating or finding niches for the development of novel tourism markets may add to economic recovery efforts and overall economic growth (Dogru et al., 2016; Dritsakis, 2004). Essentially, destination countries can boost economic growth by attracting tourists through the creation of new and novel tourism segments and by increasing demand for tourism opportunities (Dritsakis, 2004). For example, improving or incorporating novel tourism segments could mean increasing ecotourism or food and medical tourism, and by paying close attention to trends in travel and tourism.

Although both tourism and the entire economy also show economic, social, and political resiliencies towards severe climate change impacts, the effects of vulnerability to climate change are proportionally much larger in magnitude. Therefore, mitigation policies should be prioritized at a global scale, through international agreements, to reduce greenhouse gas emissions. While mitigation strategies will reduce vulnerability to climate change, adaptation strategies will increase the resiliency. The allows the economy to maintain robust health in the face of a changing climate (Cheer & Lew, 2018; Hallegatte & Corfee-Morlot, 2011; Hashemi, Bagheri, and Marshall 2017; Ofoegbu et al., 2017).

Our results indicate that specific destinations should focus on the effects climatic and non-climatic factors have on the tourism industry and the overall economy to develop efficient adaptation and mitigation strategies. Countries, on the other hand, should reduce their dependence on imported foods and increase their internal agricultural capacity, along with increasing renewable water resources, as insufficient food and water resources exacerbate climate change impacts (Isik, Dogru, & Sirakaya Turk, 2018). Overall, tourism industry stakeholders should collaborate with local farms to sustain local produce and maintain local cereal yields (Rosenzweig et al., 2013). By reducing dependence on imported resources, countries will resist changes stemming from climate change, as the global issue is likely to affect energy prices. In addition, the quality of infrastructure should be improved, as it is important for both national and international trade and investments. Furthermore, countries should establish political stability and reduce social inequality to mitigate expected climate change impacts.

While active adaptive management can aid in building resilience in socio-ecological systems (Folke et al., 2002), this can only be effectively utilized by countries or institutions that have the capacity to do so. Our results indicate that less developed countries are the most vulnerable and the least resilient to severe climate change impacts. Although less developed nations have relatively high tourism rates, their resource capital may be low due to geographic location, other forms of isolation, or a strict reliance on tourism. Likewise, richness and diversity are key components in a destination's levels of vulnerability and resilience, where low diversity correlates with low productivity, low resilience, and high vulnerability (Adger 2000, 2009).

Social and ecological heterogeneity do not always correlate to resilience, however (Charnley, Spies, Barros, White, & Olsen, 2017). Adaptive management is a structured, iterative, and robust decision-making plan that increases adaptive capacity by requiring facilitation within society, open institutions, and multi-level governance systems (Folke et al., 2002). Unfortunately, not all tourism destinations can adopt an adaptive management system due to a lack of economic strength, social development, or local governance structures. Structures that form the basis of resilient governance include decentralization, autonomy, accountability, transparency, responsiveness, flexibility, participation, inclusion, experience, and support (Tanner, Mitchell, Polack, & Guenther, 2009). In many tourism destinations today, these characteristics are weak or missing completely. Such internal structures exacerbate the difficulty of formulating adaptation and mitigation strategies to deal with climate change.

In order to increase capacity, cross-cultural networks should be forged to create and maintain alliances and relationships of reciprocity across administrative boundaries (McMillen et al., 2014; Thaman, 2008). This strengthens resilience and resource access (Thaman, 2008), as broadening social structures and creating networks builds social and economic capital (Bourdieu, 2011; Putnam, 1995). Absorbing climate changes depends on social capital and the resources present in the locale (Adger 2000, 2009). Through close association, countries that create networks and collaborate towards economic goals, including the development and maintenance of tourism, are able to shore up their differences and increase their social and political capital (Adger, 2009; Adler, 2002; Bourdieu, 2011; Putnam, 1995). Pulling out from international agreements, such as the Paris Climate Accord, will only deter such effects.

6.3. Limitations and recommendations for future research

Despite its significant contributions to the current body of knowledge on climate change and tourism, this study has some limitations. We analyzed the effects of vulnerability and resilience to climate change utilizing constructs and indicators measured at a national scale, with the best available dataset. Nonetheless, in developing future constructs, it is important to have indicators that are actionable for climate change adaptation; when possible, indicators should have the potential to be scaled down from country to provinces and, further, to cities in order to support the development of adaptation policies specific to particular regions. Therefore, it is necessary to assess the vulnerability and resilience of the tourism industry at a local scale in order to provide more accurate and applicable mitigation and adaptation strategies.

As our sample indicates, more than half of the countries in the world were not included in the sample of our study due to insufficient data. Future studies could attempt to develop alternative constructs with datasets available from these countries to analyze the effects of vulnerability and resilience on tourism or other economic activities. However, the need for this may be moot; it is evident from the findings of the present study that tourism is unilaterally vulnerable to climate change, and in fact is more vulnerable than the entire economy. Further, future research might look to determine the extent to which vulnerabilities of sub-sectors of the tourism industry vary (Rosselló-Nadal, 2014; Hall, Amelung, Cohen, Eijgelaar, Gössling, Higham, et al., 2015).

Although we showed that tourism is more vulnerable to climate change than the economy in general, we did not separately compare the vulnerability of tourism with other industries of the economy, such as agriculture, energy, etc. While tourism is more vulnerable to climate change than the overall economy, other specific industries might be *even more* vulnerable. Future researchers should examine and compare the vulnerability and resilience of the other sectors of the economy.

CRediT authorship contribution statement

Tarik Dogru: Conceptualization, Methodology, Writing – original draft. **Elizabeth A. Marchio:** Writing – original draft, Writing – original draft. **Umit Bulut:** Formal analysis, Writing – original draft. **Courtney Suess:** Writing – original draft, Writing – original draft.

Appendix 1

Low Income Tier Countries	Middle Income Tier Countries	High Income Tier Countries
Armenia	Albania	Australia
Bangladesh	Algeria	Austria
Belize	Azerbaijan	Belgium
Bhutan	Belarus	Canada
Bolivia	Bulgaria	Czech Republic
Cambodia	Chile	Denmark
El Salvador	China	Estonia
Guatemala	Colombia	Finland
Honduras	Costa Rica	France
India	Croatia	Germany
Indonesia	Dominican Republic	Greece
Jamaica	Ecuador	Hungary
Kenya	Egypt	Iceland
Kyrgyzstan	Jordan	Ireland

Lesotho	Kazakhstan	Israel
Malawi	Latvia	Italy
Moldova,	Macedonia	Japan
Nepal	Mauritius	South Korea
Nicaragua	Mexico	Lithuania
Nigeria	Mongolia	Malaysia
Pakistan	Panama	Netherlands
Papua New Guinea	Peru	Norway
Paraguay	Romania	Poland
Philippines	Russian Federation	Slovakia
Rwanda	South Africa	Slovenia
Sudan	Sri Lanka	Spain
Swaziland	Thailand	Sweden
Uganda	Tunisia	Switzerland
Ukraine	Turkey	United Kingdom
Yemen	Uruguay	United States

Appendix 2

Vulnerability Components
Food
Projected change of cereal yields
Food import dependency
Agriculture capacity
Projected population change
Rural Population
Child malnutrition
Water
Projected change of annual runoff
Fresh water withdrawal rate
Access to reliable drinking water
Projected change of annual groundwater recharge
Water dependency ratio
Dam capacity
Health
Projected change of deaths from climate change induced diseases
Slum population
Medical staffs
Projected change of length of transmission season of vector-borne diseases
Dependency on external resource for health services
Access to improved sanitation facilities
Ecosystem
Projected change of biome distribution
Dependency on natural capital
Protected biomes
Projected change of marine biodiversity
Ecological footprint
Engagement in International environmental conventions
Human Habitat
Projected change of warm period
Urban concentration
Quality of trade and transport-related infrastructure
Projected change of flood hazard
Age dependency ratio
Paved roads
Infrastructure
Projected change of hydropower generation capacity
Dependency on imported energy
Electricity access
Projection of Sea Level Rise impacts
Population living under 5 m above sea level
Disaster preparedness
Resilience Components
Doing business
Political stability and non-violence
Control of corruption
Rule of law
Regulatory quality
Social Readiness
Social inequality
ICT infrastructure
Education
Innovation

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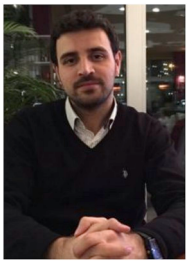

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